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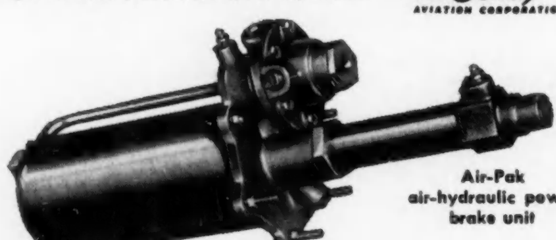
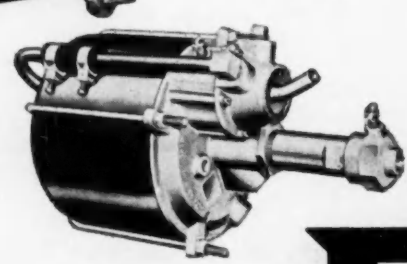


Air-Pak air-hydraulic power brake unit



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Fourth in LPG Series

This is the fourth in SAE Journal's series on liquefied petroleum gas as an automotive fuel.

Other articles in the series were digested from SAE papers by Leonard Raymond, F. E. Selim, R. C. Alden, and A. J. St. George.

LPG Raises
Cuts

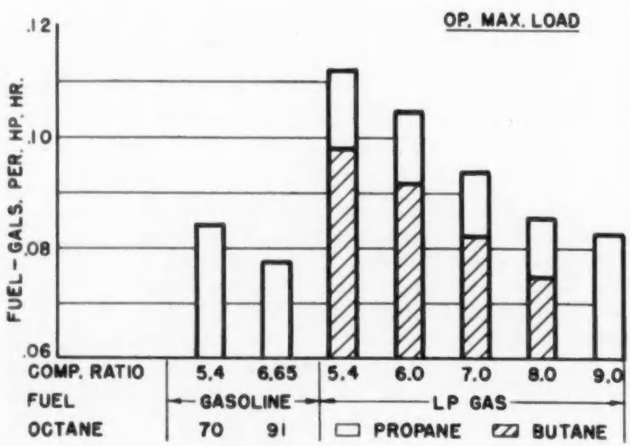

Fig. 1—Specific fuel consumption at operating maximum load

TRACTOR engine specific fuel consumption in gallons per horsepower-hour is generally higher with liquefied petroleum gas than with gasoline. But engine maintenance costs are lower with LPG.

Reasons behind this conclusion on fuel consumption are given in the series of fuel economy bar graphs, Figs. 1-5. These data are averages for a large number of tests conducted by the Minneapolis-Moline organization during the past 10 years. Comparison is made between 70 and 91 octane gasolines and LPG for compression ratios from 5.4:1 to 9.0:1. The graphs illustrate the fuel consumption at five loads that are usually taken to obtain the part-load curve on a given engine. (These are the loads taken in the Nebraska test.)

The "operating maximum" is the setting of the carburetor for near-maximum performance with good fuel economy. The "rated load" is 85% of the observed horsepower reading corrected to sea level conditions. The 75%, 50%, and 25% loads are percentages of rated load, not of maximum. The specific fuel consumption has been converted to gallons per horsepower-hour to give a more direct comparison between LPG and gasoline. This is done

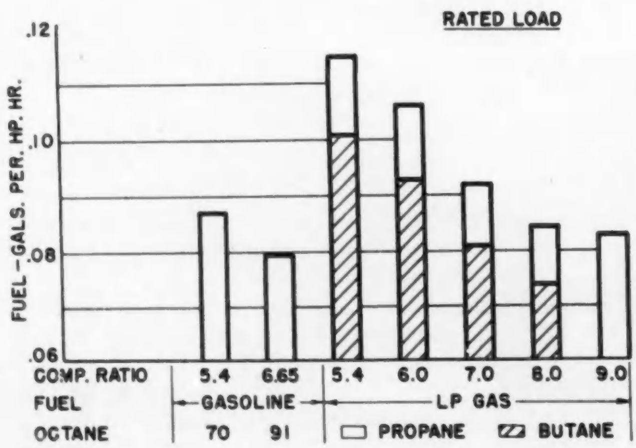

Fig. 2—Specific fuel consumption at rated load

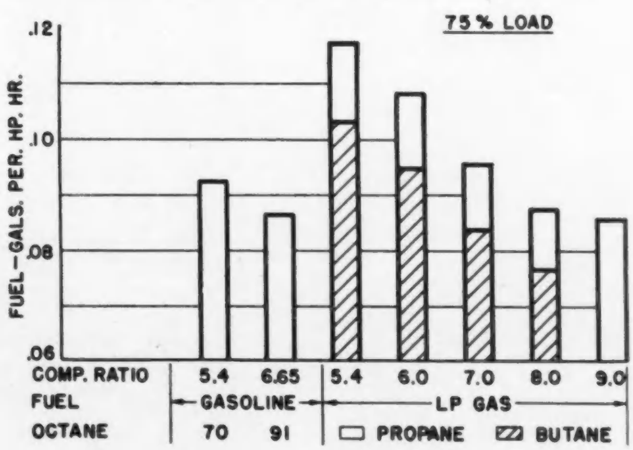

Fig. 3—Specific fuel consumption at 75% load

Fuel Consumption, Maintenance in Tractors

EXCERPTS FROM PAPER BY

Marvin J. Samuelson, Field Research Engineer, Minneapolis-Moline Co.

• Paper, "Comparative Operating Data of Tractor Using Gasoline or Liquefied Petroleum Gas Fuel" was presented at SAE Annual Meeting, Detroit, Jan. 8, 1951.

to overcome the unfair comparison that would result if pounds per horsepower-hour were compared, inasmuch as LPG weighs less per gallon than gasoline.

The bars for LPG have a shaded and an unshaded part for all compression ratios except 9.0:1. The unshaded bars represent the fuel consumption that would be expected when 100% propane is used, and the shaded portion represents the fuel consumption of 100% butane. The maximum compression ratio that can be used for butane is approximately 8:1 and is the ratio where detonation begins to appear.

In comparison with 70 octane gasoline at a compression ratio of 5.4, the specific fuel consumption of propane is higher at operating maximum—except on the 9.0:1 LPG compression ratio. The ratio at the point where the specific fuel consumptions of propane and 70 octane gasoline are equal, is progressively lower as the load is reduced. With 91 octane gasoline and a compression ratio of 6.65, the specific fuel consumption is lower on the gasoline than on propane at all LPG compression ratios until the 75% load or less is reached. At this load and below, the specific fuel consumption is lower on propane.

Butane at 8.0:1 compression ratio shows better economy than either 70 octane or 91 octane gasoline at their compression ratios. However, butane shows the same trend as propane, which is toward a lower ratio for equal specific fuel consumption at the lower loads. Consequently, it is desirable from from the point of operation to have as much butane in the LPG as possible wherever engines having compression ratios below 8:1 are used.

In all farming operations, a certain amount of idling takes place. Partial loads are the general rule, so any comparison between fuel consumption of LPG and gasoline should take idling into consideration.

Fig. 6 shows the fuel flow in gallons per hour of a Minneapolis-Moline Model U tractor as taken from Nebraska Tests 411 and 319. Test 411 was made with an LPG engine and all power-consuming accessories on the tractor. Test 319 was run with a gasoline engine, without some of the accessories. In order to make a fair comparison between the two fuels, we have made a slight correction in the gasoline power output to compensate for difference in accessories. Fuel consumption difference tends

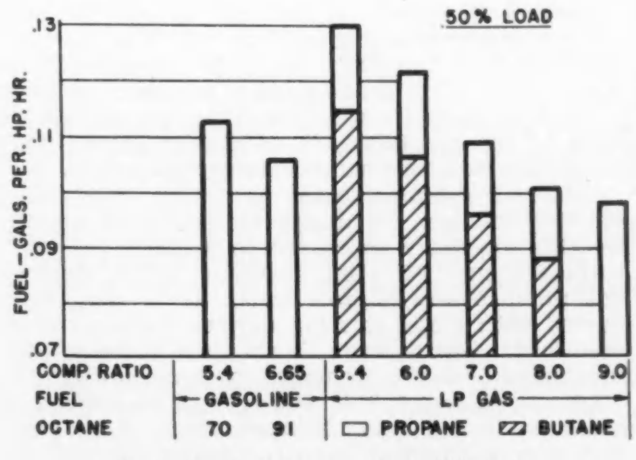

Fig. 4—Specific fuel consumption at 50% load

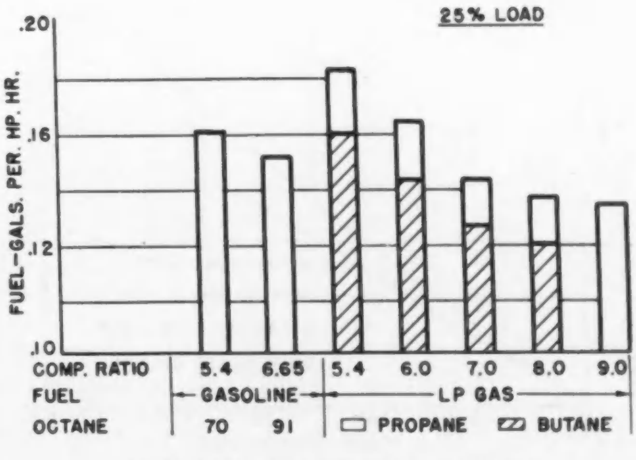

Fig. 5—Specific fuel consumption at 25% load

to become smaller at the lighter loads and favors LPG slightly at the low end.

If propane and gasoline are compared at approximately 35 hp, fuel consumption of propane reads approximately 18% greater than that of gasoline. This figure has been established as the answer to the numerous inquiries we receive as to fuel consumption of LPG compared to gasoline. It is believed that the figure will not be greater—but could be a good deal less unfavorable to LPG, if loads are light and the LPG mixture contains a considerable portion of butane. Operators having considerable butane in their LPG generally confirm that the 18% figure is high if their loads are light.

In a comparison of the fuel consumption of two tractors of the same model, one using gasoline and the other LPG, it was found after 5000 to 6000 hr of comparatively heavy work, that fuel consumption of the LPG tractor was approximately 18% greater. This was with the compression ratio of each engine appropriate to its fuel.

Good fuel economy in actual practice depends not only on efficient utilization in the tractor. There are shrinkages that take place to reduce the overall fuel economy through handling, evaporation losses, and pilferage. Losses that do not become apparent to many operators are spillage during transfer and fuel vapor escape through the gasoline tank vent, especially in hot weather operation. Tests indicate that losses as high as 3% can be obtained where surrounding air temperatures are high. Pilferage has been a problem in some cases where employees have access to the fuel storage tank. The special equipment necessary for LPG has generally eliminated this loss completely.

Most operators fill LPG tanks by bleeding vapor, which introduces a chance for loss. Tests indicate that in the flow through a No. 54 orifice (0.0465 sq in.), the loss is approximately 0.1 lb per min. (This is the largest orifice permitted by safety regulations.) Calculations based on the time to fill an average tank show that this loss could be expected not to exceed 1%.

LPG contains no lead-salt additives, burns clean, and leaves no deposits. Inasmuch as LPG is admitted as a gas, dilution problems are minimized or eliminated and cylinder wall lubrication is improved. Most present-day engines utilizing LPG do not have compression ratios high enough to reach the detonation limit, so the effects of detonation on wearing parts are not present. In view of these facts it is expected that lubrication problems will be reduced where LPG displaces gasoline.

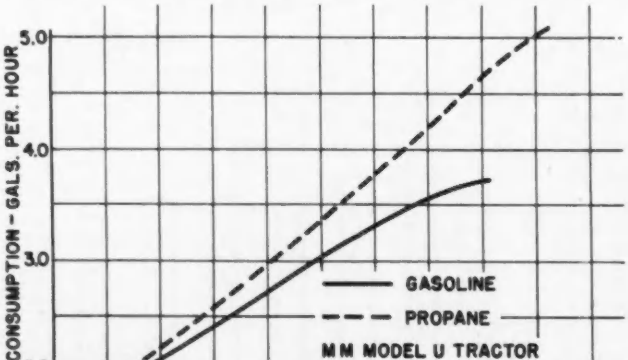

Fig. 6—Comparison of gasoline and propane consumption by a Minneapolis-Moline Model U tractor using gasoline and propane

It is also expected that the engine can operate safely for longer periods between drains. Farmers report that with LPG they are doubling drain periods set for gasoline operation. Many Southern plantation owners have followed the practice of changing the lubricant in the crankcases of their LPG engines only every 300 hr. They are seemingly having no decrease in performance or increase in maintenance.

Manufacturers are, of course, sometimes hesitant to recommend longer drain intervals because condensation problems develop in cold-weather operation. Under these conditions, it is generally better for the operator to drain his crankcase frequently than to risk condensation and sludge.

Operators are obtaining unusually long valve life with LPG. For example, operators of Minneapolis-Moline LPG tractors obtain three, four, and sometimes five seasons of service before valves require attention. In contrast, Kansas farmers in a planned maintenance program service gasoline-engine valves at the end of each season. Long life of the LPG-engine valves is attributed to the hardened steel valve inserts.

General observations of fleet tractors returned to the factory for inspection are that:

1. LPG engines take longer to reach a given increased oil consumption than gasoline engines.

2. LPG engines develop less carbon deposit, and pistons and rings are generally free of the deposits normally found with gasoline engines.

3. Comparison of the degree of wear on cylinders and rings with the two fuels seems to indicate a slight advantage for LPG.

Many operators of Minneapolis-Moline tractors report that they can use rings, pistons, and cylinders twice as long with LPG as with gasoline.

Southern plantation owners have been converting to LPG as fast as they can. They are in an area, of course, where the price of LPG is considerably more favorable than in some other sections of the country. They estimate a 20% saving in maintenance cost with LPG over gasoline.

Very little maintenance has been needed by regulator and carburetor equipment. About the only trouble experienced comes from fuel that has not been scrubbed thoroughly enough to remove all of the absorption oil used in manufacturing the LPG. If this oil finds its way into the heat exchanger coils of the regulators, it eventually causes poor regulation and very unsatisfactory operation.

Under low-temperature operating conditions, starting has been an unexpected source of trouble. Heating the water jacket has so far been the most successful cure. Heating incoming fuel or air does not produce any improvement. Some tests conducted with diesel starting devices, such as ether manifold injectors, have shown them to be helpful in starting LPG engines under subzero conditions.

(Paper on which this abridgment was based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Combustion-Chamber DEPOSITS

TWO sessions of the SAE Summer Meeting, held at French Lick, Ind., June 3-8, 1951, were devoted to a review of present knowledge on the effects of combustion-chamber deposits on knock. Both sessions were sponsored by the Fuels & Lubricants Activity of the SAE.

At the morning session two papers and discussions were presented that brought the audience up to date on the results of recent road tests designed to reveal more precisely (1) how combustion-chamber deposits form, (2) how they influence knock, and (3) what the effects are.

Both papers and all discussions will be published in full in SAE Quarterly Transactions

L. F. DUMONT, E. I. DUPONT DE NEMOURS & CO., INC., IN HIS PAPER "POSSIBLE MECHANISMS BY WHICH COMBUSTION-CHAMBER DEPOSITS ACCUMULATE AND INFLUENCE KNOCK," reported that the increase in surface temperatures as deposits accumulate appears to be the main factor responsible for limiting the quantity of deposits formed in engines. For leaded fuels, he said that the temperature gradient across the deposits from the surface to the metal wall and the thermal stresses accompanying this gradient eventually reach a critical value, which causes deposit flaking to occur. That deposit surface temperatures increase substantially is indicated by the changes in chemical composition that occur as deposits accumulate.

This author discussed three mechanisms by which deposits could increase octane requirement: (1) deposit volume, which accounts, he said, for 20-40% of the octane requirement increase, due to the increase in compression ratio; (2) catalysis, which did not seem to be a factor in these tests, especially for leaded fuel; and (3) thermal insulating effect of deposits, which appears to be one of the major causes of deposit knocking harm. An extensive abridgment of this paper appears in this issue beginning on .... p. 22

J. B. DUCKWORTH, STANDARD OIL CO. (IND.), SPOKE ON "EFFECTS OF COMBUSTION-CHAMBER DEPOSITS ON OCTANE REQUIREMENT AND ENGINE POWER OUTPUT." In this paper he showed that (1) under typical passenger-car service, deposits may be expected to increase octane requirements 8-12 units, irrespective of the tel content of the fuel (that is, octane-number gain from the addition of tel is not nullified by the increase in octane requirements); and (2) torque loss attributable to deposits seems to be greater with L-head than with overhead-valve engines. (Incorporation of automatic or torque-responsive transmissions adds to the importance of this problem simply because satisfactory operation of these devices depends on maintenance of design torque.) An extensive abridgment of this paper appears in this issue beginning on .... p. 28

Supplementing these two papers were two discussions, prepared by J. F. Kunc, Standard Oil Development Co., and C. A. Hall, Ethyl Corp.

Mr. Kunc presented data that showed the rate of deposit buildup and the change in octane requirement when hydrogen is used as a fuel. In addition, he showed a plot of rate of octane requirement increase versus initial octane requirement. These data indicate that, with higher initial requirement (clean engine), the increase in requirement with subsequent operation takes place at a smaller rate.

Mr. Hall explained that in tests with solidly packed washers placed in a combustion chamber, there was no change in octane requirement. In the next phase of this experiment, the washers were spaced so that the full area of each was exposed to the incoming charge. This resulted in an increase in requirement, indicating that the heat absorbed by the washers during the firing stroke was transferred to the incoming fuel and air mixture during the intake and compression strokes. These data emphasized the thermal effects on requirement increase.

AT THE AFTERNOON QUESTION AND ANSWER FORUM, questions that had been submitted at the close of the morning session were directed by the moderator to members of a panel of experts in the engine-fuel field. (Their names are given later in connection with their photograph.) They are shown in the photograph on page 33. A report covering the questions, with answers by various members of the group, appears in this issue beginning on p. 31

How Deposits May

SINCE road and laboratory scavenging test information indicates that the proknock effect of combustion-chamber deposits cannot be explained simply in terms of either deposit weight or chemical composition, investigations have been conducted to determine how deposits increase octane requirement. As a result of these investigations it is postulated that deposit knocking harm is a result of three main effects:

1. Volume.
2. Catalysis.
3. Thermal insulation.

Volume

Deposits significantly increase the compression ratio of an engine and therefore would be expected to increase the octane requirement. The contribution of this factor to deposit knocking harm was investigated in a single-cylinder ASTM supercharge method engine using both valve-in-head and L-head cylinders.

The method used is illustrated in Fig. 1. The variation in octane requirement with change in compression ratio was determined for the clean engine. Tests were then conducted for 70 hr. during which the total knocking harm of the combustion-chamber deposits was measured. At the conclusion of the test the volume of the deposits was determined (a) in place on the engine surfaces by measuring the clearance volume with water, and (b) by measuring the volume of the scraped deposits in water. The increase in compression ratio for the measured decrease in clearance volume was calculated and thus the corresponding increase in clean-engine octane requirement due to the deposit volume could be determined.

The results of such tests conducted with unleaded fuel and fuel containing 3.0 ml tel per gal are summarized in Fig. 2. These data indicate that:

1. The physical volume of combustion-chamber deposits appeared to account for 10 to 47% of the total deposit knocking harm.

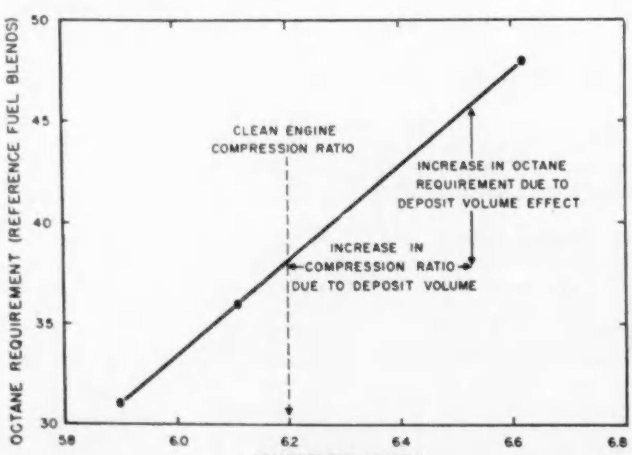

Fig. 1—Method used to determine contribution of deposit volume to octane requirement increase in ASTM supercharged method engine

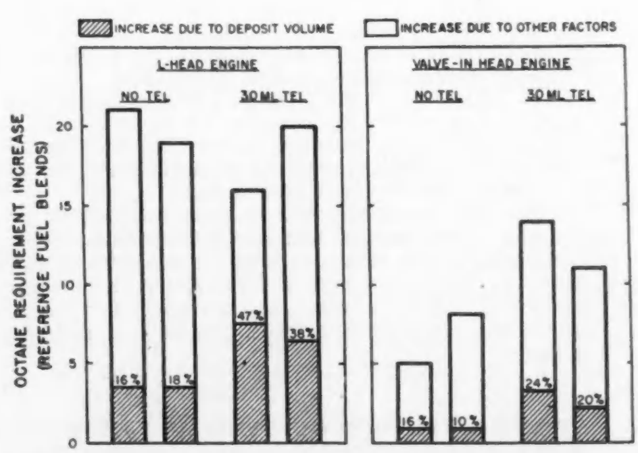

Fig. 2—Contribution of combustion-chamber deposit volume to octane requirement increase

Combustion-Chamber Deposits

Influence Knock

EXCERPTS FROM PAPER BY

L. F. Dumont, Petroleum Laboratory, E. I. duPont de Nemours & Co., Inc.

• Paper, "Possible Mechanisms by Which Combustion-Chamber Deposits Accumulate and Influence Knock," was presented at the SAE Summer Meeting, French Lick, Ind., June 5, 1951. (This paper will be published in full in SAE Quarterly Transactions.)

2. The contribution of leaded fuel deposit volume to octane requirement increase was generally twice as great as that of the unleaded fuel deposits.

These results have been confirmed by similar experiments conducted in other engines. The data from all these experiments indicate that, in general, 20 to 40% of the octane requirement increase is due to the effect of the deposits on compression ratio. In addition, it has also been confirmed that the knocking harm per unit volume of unleaded fuel deposits is approximately twice as great as that for leaded fuel deposits.

Conversely, the data show that 60 to 80% of the deposit knocking harm is the result of factors other than deposit volume. If these factors could be counteracted by physical or chemical modifications of the deposit, then a substantial portion of deposit knocking harm could be eliminated without necessarily reducing the amount of deposit present. That such a solution to the problem is a possibility has already been demonstrated through the use of boron compounds, which reduce octane requirement increase, although they do not improve combustion-chamber deposit scavenging.

Catalysis

In an attempt to isolate and establish the contribution of catalysis to deposit knocking harm, tests were conducted in which the effects of various dusts on the octane requirement of a deposit-free engine were determined. Since the walls of the engine were clean and since the deposits were introduced in the form of finely divided particles suspended in the intake mixture, it was reasoned that a deposit catalytic effect on knock could be measured in the absence of deposit compression ratio effects and other mechanisms associated with deposit-coated combustion-chamber walls.

The tests were conducted by operating a single-cylinder engine on blends of primary reference fuels at trace knock and injecting dusts at controlled rates into the intake air stream while varying the

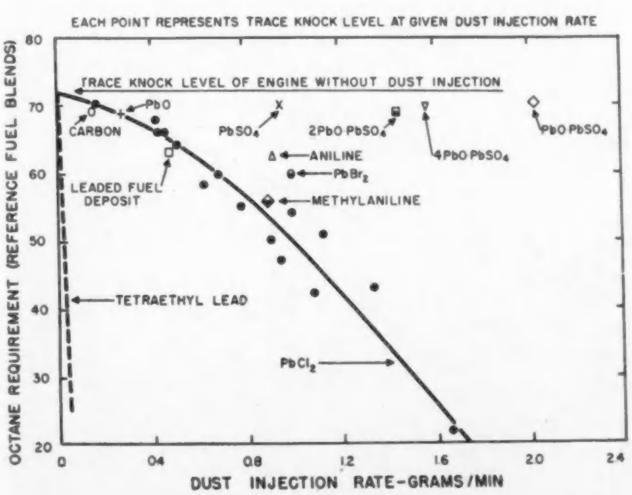

Fig. 3—Effect on knock of combustion-chamber deposits and several of their individual constituents when introduced into combustion chamber as finely divided particles

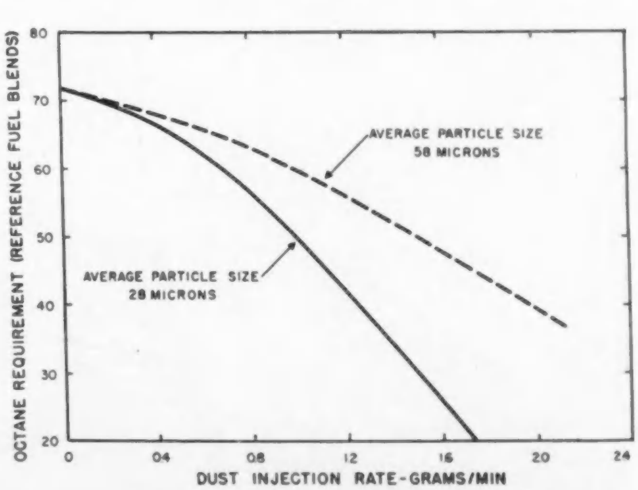

Fig. 4—Effect of particle size on antiknock activity of finely divided lead chloride

octane number of the reference fuel blend to maintain trace knock. The results of a number of such tests are summarized in Fig. 3.

The octane requirement of the engine without dust injection was 72. With the injection of dusts prepared by powdering deposits removed from the piston top of an engine operated on leaded fuel, the octane requirement was reduced from 72 to 63, a 9-octane-number antiknock effect. Powdered carbon similarly reduced the octane requirement three units. Various constituents of leaded fuel deposits were also injected, including lead chloride, lead bromide, lead oxide, lead sulfate, and several lead oxysulfates. None of these materials exerted proknock effects. The antiknock effect of lead chloride dust was investigated over a range of injection rates. As shown in Fig. 3, lead chloride at an injection rate of 1.7 g per min reduced the octane requirement of the engine from 72 to 20.

That the antiknock effects of these dusts were substantial is shown by comparing the curve for lead chloride with the antiknock effects obtained in this engine with aniline and methylaniline. However, lead chloride was only about 1% as effective as tetraethyl lead under these particular conditions. It should be pointed out that these relative antiknock effects would probably be different in other engines.

In order to establish whether or not the antiknock effects observed were due to changes in the mass rate of burning of the charge, pressure-time diagrams were obtained during dust injection into an ASTM supercharge method engine. Analyses of these diagrams indicated no change in the mass rate of burning, although large antiknock effects due to the injection of dusts were observed. For example, the injection of 1 g of lead chloride dust per minute reduced the octane requirement of this engine from 92 to 84. On the basis of equivalent dust/fuel ratios, the antiknock effects in the two engine types used were almost identical. Similar results were obtained with powdered leaded fuel combustion-chamber deposits.

At least one disadvantage to this method of investigating the catalytic effects of combustion-chamber deposits is the possibility that the temperature of the dust particles is not as high as the temperature of deposits on the wall during the early stages of the cycle when the reactions which lead to knock are initiated. Deposits on the wall could affect these early reactions by catalytic means, whereas the dust particles might not become hot enough, and therefore catalytic, until after the reactions had proceeded beyond a critical stage. The fact that antiknock effects rather than proknock effects were observed, however, indicates that the dusts entered into these reactions early enough to alter their course. Moreover, the decomposition products of the dust remaining in the residual exhaust gas would probably be hot enough to exert catalytic effects very early in the subsequent cycle.

If increasing the temperature of the particles were to cause the dusts to become proknocks, then it would be expected that this effect could be accomplished by decreasing the dust particle size. However, as shown in Fig. 4, decreasing the particle size of lead chloride dusts from an average of about 58 microns to 28 microns had the effect of substantially increasing the antiknock effect.

Further evidence that combustion-chamber deposits do not serve as catalysts for accelerating the knock reaction is indicated by the results of motored engine precombustion reaction investigations reported by others. The reference data showed that

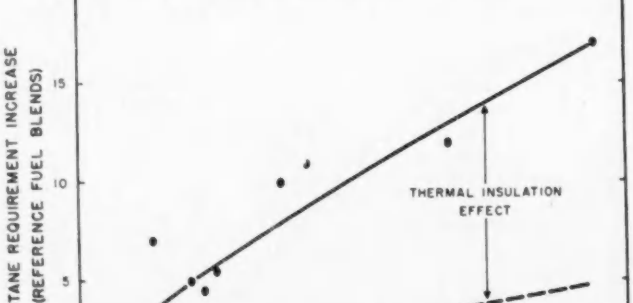

Fig. 5—Effect on octane requirement of catalytically inert, low heat conductivity combustion-chamber deposits consisting of polytetrafluoroethylene ("Teflon") cylinder-head coatings

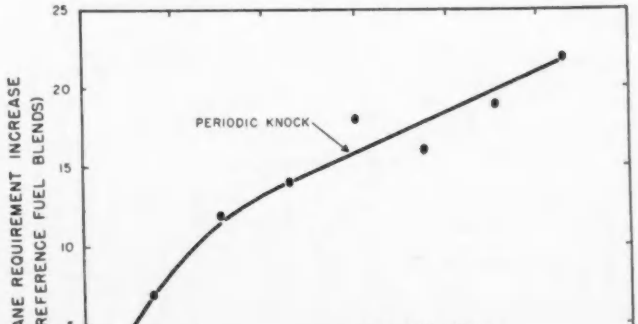

Fig. 6—Effect of knock on octane requirement increase of deposits formed with fuels containing 3 ml tel per gal

precombustion reactions were suppressed as much by coating the engine walls with lead oxide as they were by the addition of 4.6 ml tel per gal to the fuel. Extrapolation of data on catalytic effects in a motored engine, in which combustion-chamber surface temperatures are much lower than in a fired engine, must be done with great caution. Nevertheless, it is of interest to note that the conclusions which might be drawn from two independent engine investigations are in agreement.

The results of these dust injection experiments indicate that catalysis may not be an important factor contributing to octane requirement increase. However, it is conceivable that surface reactions involving glowing particles could cause catalytic effects on knock. Corn-flake type deposits, which appear to have been incandescent at some locations, and similar unusual types of deposits could possibly have catalytic effects. The fact that the volume contribution of unleaded fuel deposits to octane requirement increase is significantly smaller than for leaded fuels suggests that catalysis might be more important for unleaded fuel deposits.

Although combustion-chamber deposits themselves may not be catalytic, it is possible that their harm, by whatever mechanism it occurs, could be counteracted by incorporating as part of the deposit other materials which could exert a very pronounced antiknock effect on end-gas reactions.

Thermal Insulation

That the surface temperature of combustion chamber deposits increases substantially with deposit thickness is indicated by the changes in chemical composition of the successive deposit layers. The increase in deposit surface temperatures could cause a substantial increase in end gas temperatures and therefore octane requirement by:

1. Heating the charge drawn into the cylinder.

2. Reducing the rate of heat dissipation from the hot compressed working fluid during compression of the end gas by the piston and by the advancing flame front.

It was suggested as early as 1925 that combustion chamber deposits have significant thermal insulating properties. A quantitative measure of this effect was reported in 1940. In addition, it is well known that raising combustion chamber surface temperatures by increasing engine coolant temperatures promotes knock; however, the relationship between the thermal insulating effect of deposits and octane requirement has not been established.

Tests conducted in this laboratory with single-cylinder engines have indicated that catalytically inert films of low thermal conductivity increase octane requirement substantially over and above their volume effects. Polytetrafluoroethylene was used since it is noncatalytic, a very poor heat conductor, and is also capable of surviving engine operation when it is fused on the combustion-chamber walls in thin films. In these tests the coatings were prepared by spraying a dispersion of polytetrafluoroethylene in water on the cylinder head. The coating was slowly dried so that a thin, continuous film of uniform thickness was formed and was then fused at 750 F with a torch. The effect of the film on the octane requirement of the

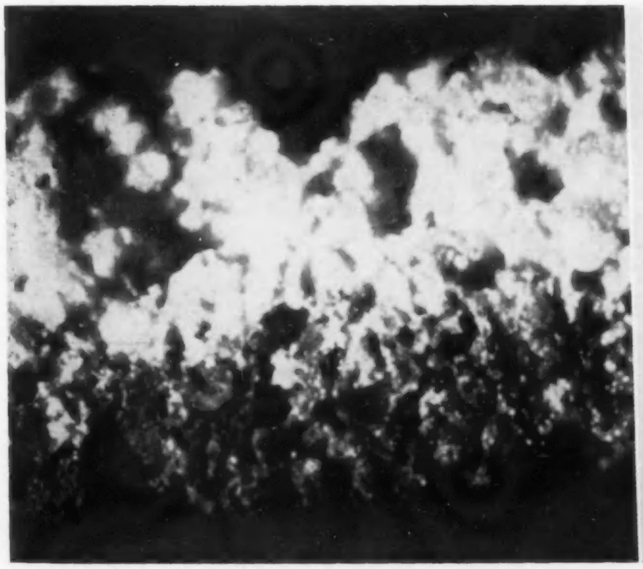

Fig. 7—Cross-section of leaded fuel deposit accumulated on piston top—greatly enlarged

Fig. 8—Cross-section of leaded fuel deposit accumulated under continuous knocking conditions—greatly enlarged

otherwise clean engine was then determined. Following each test the polytetrafluoroethylene film was stripped from the metal and its actual thickness determined. The results of these tests, given in Fig. 5, indicate that the octane requirement increased almost in direct proportion to the thickness of the film. The calculated volume effect of the films on octane requirement was measured in a manner similar to that shown in Fig. 1 and was found to account for only 25% of the total increase in octane requirement observed. The thermal insulating effect of the film, therefore, caused 75% of the octane requirement increase. The fact that an insulating coating only 0.011 in. thick on the cylinder head increased the octane requirement 17 units is highly significant, since the thickness of equilibrium combustion-chamber deposits is usually several times greater.

Further evidence that deposit weight and chemical composition alone do not completely define the knocking harm of combustion-chamber deposits was obtained in single-cylinder engine tests in which deposits were accumulated under continuous trace knocking conditions. The effect of continuous knock on octane requirement increase in these particular experiments is shown in Fig. 6. The deposits accumulated with a low-sulfur gasoline containing 3.0 ml tel per gal caused an average increase in octane requirement of 22 units in three tests. The knocking harm of the deposits was measured at 15-hr intervals so that at these intervals they were subjected to light knock and, therefore, a moderate amount of overheating. When the extent of deposit overheating was increased substantially by operating continuously under incipient knocking conditions, the average octane requirement increase was only two units in two tests. Continuous knock was obtained by blending 3.0 ml tel per gal with primary reference fuels so that the octane number of the leaded fuel exceeded the clean-engine octane requirement by about two octane numbers. Under these conditions knock became audible at irregular intervals for short periods during the test, indicating that the octane requirement tended to exceed the octane quality of the fuel but was suppressed by some physical or chemical modification of the deposit by the overheating which occurred.

Although there were small changes in deposit chemical composition and a reduction in the weight of deposits, as shown in Table 1, such differences could by no means account for the decrease in deposit knocking harm.

The deposits accumulated under knocking conditions appear to be substantially more dense than those formed during nonknocking operation. This may be seen by comparing the enlarged photographs of deposit cross-sections in Figs. 7 and 8. Deposits subjected to continuous knock seem to be lacking in a definite carbonaceous layer, appear to have been molten, and, most important, are substantially less porous. All these factors suggest that the reduced harm of deposits accumulated under continuous knocking conditions is the result of the formation of denser deposits which have lower thermal insulating properties.

Preliminary attempts to duplicate these effects of knock on octane requirement increase in a multicylinder engine were unsuccessful; nevertheless, the single-cylinder engine data leave no doubt that under certain conditions octane requirement increase can be limited by knock. Although the exact reasons for the failure to duplicate these results in a multicylinder engine are not known, it is felt that

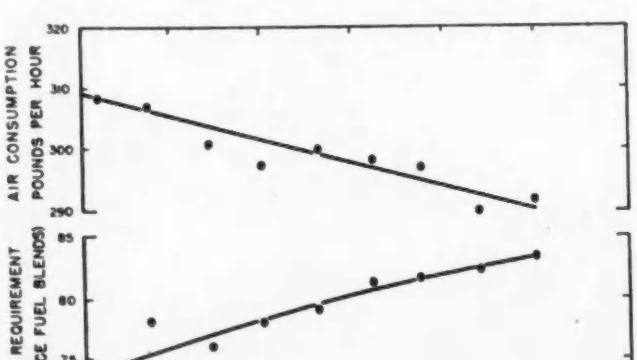

Fig. 9—Effect of deposit accumulation on octane requirement and air consumption. Laboratory multicylinder L-head engine operated under steady, light-duty conditions using fuel containing 3 ml tel per gal

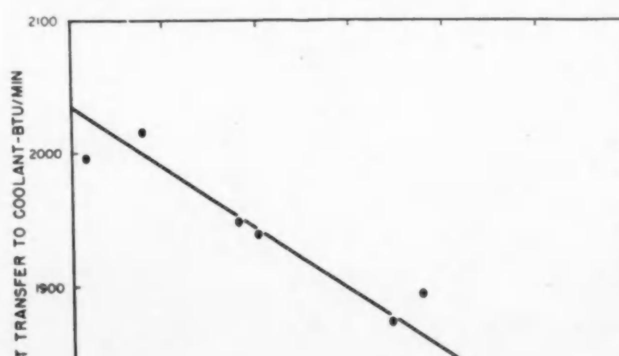

Fig. 10—Effect of deposit accumulation on heat transfer to coolant. Laboratory multicylinder L-head engine operated under steady, light-duty conditions using fuel containing 3 ml tel per gal

it may be linked to the fact that continuous knock did not occur in all cylinders.

Direct evidence has been obtained which indicates that a considerable fraction of deposit knocking harm is caused by the thermal insulating effect of combustion-chamber deposits. These tests were conducted in a multicylinder L-head engine equipped so that the heat transferred from the combustion-chamber working fluid to the coolant could be both measured and controlled. The effect of deposit accumulation on octane requirement, engine air consumption, and heat rejection to the coolant at constant coolant outlet temperature during 100-hr tests using a fuel containing 3.0 ml tel per gal is shown in Figs. 9 and 10. The data indicate that the deposits caused a 10-unit increase in octane requirement, a 6% loss in air consumption, and a 230 Btu per min or 11.3% loss in coolant heat rejection.

Since these tests were conducted at constant air/fuel ratio, the loss in heat rejected to the coolant is the result of two main effects: (a) the thermal insulating effect of the deposits, and (b) a reduction in total heat released by the working fluid. The reduction in the amount of heat released in the cylinder accounted for about one-half of the total observed loss in heat transferred to the coolant. The loss in coolant heat transfer caused by the deposit thermal insulating effect alone, if transferred entirely to the incoming charge, could have had the effect of increasing the charge temperature 84 F. Combustion-chamber deposits, therefore, appear to be effective thermal insulating materials.

The effect of heat transfer to the coolant on octane requirement was determined in the clean engine by changing coolant temperatures with the results given in Fig. 11. In addition, the loss in heat transfer and the increase in octane requirement caused by deposit accumulation are cross-plotted from the faired curves for comparison. The data indicate that a loss in heat rejected to the coolant of 230 Btu per min, the same as that caused by deposit accumulation, had the effect in a clean engine of increasing the octane requirement approximately 5 octane numbers. Since, so far as the working fluid is concerned, it makes no difference whether the loss in heat transfer occurs by adding thermal resistance at constant coolant temperature (that is, by accumulating deposits) or by changing coolant temperatures for a given wall thermal resistance, it appears that about 5 octane numbers or 50% of the knocking harm was due to the thermal insulating effect of deposits.

Thermal insulation also appears to be a major factor accounting for loss in air consumption and, therefore, power loss. In a fired engine the loss in air consumption could be due to two deposit effects: (a) thermal insulation, and (b) throttling. In a motored engine, however, only deposit throttling effects can affect air consumption since there is very little, if any, heat loss to the walls except that due to friction. The results indicate that the deposits which caused a 6.5% loss in air consumption in a fired engine had virtually no effect on air consumption in the motored engine. Since the restrictions to airflow which deposits impose on engine breathing are identical under motoring and firing conditions, this would indicate that deposit thermal insulation is a major factor affecting air consumption loss, and hence, power loss.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

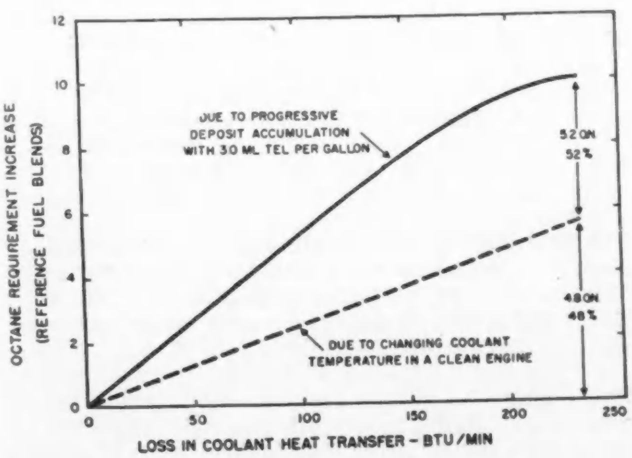

Fig. 11—Contribution of leaded fuel deposit thermal insulation to octane requirement increase

Table 1—Effect of Continuous Knock on Deposit Knocking Harm and Chemical Composition

	Extent of Knock	
	Each 15 Hr	Continuous
Octane-Number Requirement Increase	22	2
Total Deposit Weight, g	10.5	7.7
Deposit Composition, weight %		
Lead	72.2	78.3
Chlorine	8.2	11.1
Bromine	7.3	2.3
Sulfur	1.3	0.3
Carbonaceous Material	2.9	0.4
Oxygen (by difference)	8.1	7.6

Effects of Combustion–

Table 1—Inspection Data—Gasoline Used in Service Tests

Gravity, deg API		59.0
Reid Vapor Pressure, psi		9.2
ASTM Distillation, F		
Initial		104
10% Evaporated		121
50% Evaporated		210
90% Evaporated		315
End Point		374
Sulfur, % by weight		0.09
ASTM Gum, mg/100 cc		1.6
Octane Number		
ASTM Motor:	Clear	74.1
	1.0 ml Tel	79.5
	3.0 ml Tel	83.0
ASTM Research:	Clear	83.4
	1.0 ml Tel	89.0
	3.0 ml Tel	92.8

Table 2—Quantity of Combustion-Chamber Deposits

Tel Content, ml per gal	Total Weight, g			Weight, g per cu in. of Clearance Volume		
	0	1	3	0	1	3
Car						
A-1	21.3	40.9	48.8	0.54	1.03	1.22
A-2	18.6	67.8	55.2	0.75	1.71	1.39
B	24.0	78.3	70.9	0.58	1.88	1.70
C-1	27.2	53.1	55.0	0.65	1.36	1.40
C-2	21.4	67.6	53.8	0.55	1.72	1.37
D	13.7	19.5	—	0.44	0.63	—
Average	—	—	—	0.59	1.39	1.18

Table 3—Effect of Tel Content on Octane-Number Requirements

Tel Content, ml per gal	Initial Requirement			Requirement after 10,000 Miles: Deposits Present			Requirement after 10,000 Miles: Deposits Removed		
	0	1	3	0	1	3	0	1	3
Car									
A-1	74.5	75.5	74.5	85.5	87.5	81.5	75.0	75.0	79.5
A-2	73.5	74.5	72.5	86.0	87.5	88.5	75.5	78.0	76.0
B	72.5	68.0	69.5	84.5	75.0	79.5	72.5	64.5	69.0
C-1	71.5	73.0	75.0	83.0	87.5	83.5	72.0	78.5	73.5
C-2	72.5	75.5	76.5	82.0	85.5	82.0	79.0	75.5	76.0
D	53.0	60.0	—	68.5	74.5	—	55.0	59.5	—

A SERIES of road tests designed to evaluate the effects of combustion-chamber deposits on the octane requirement and power output of an engine indicate that:

- Under typical passenger-car service, deposits may be expected to increase octane requirements 8–12 units, irrespective of the tel content of the fuel (that is, octane-number gain from the addition of tel is not nullified by the increased in octane requirements).
- Torque loss attributable to deposits seems to be greater with L-head than with overhead-valve engines.

Test Tools and Experimental Work

A base gasoline was selected which had an unleaded octane number sufficiently high to permit operation without detonation throughout the course of the test work. This gasoline was typical of premium-grade base stocks and contained predominantly cracked and hydroformed naphthas. Two other fuels were prepared by adding tetraethyl lead in the form of motor fuel mix to the base gasoline in concentrations of 1 and 3 ml per gal. Inspection data are listed in Table 1.

The lubricating oil used was a premium-grade solvent-extracted SAE 20 oil containing an oxidation inhibitor and a detergent additive. Crankcase oil was changed at 2000-mile intervals.

Six postwar automobiles of four makes in the popular-priced field were employed in this work. Duplicates were provided in two instances to provide a measure of differences between cars of the same make and model. The cars are identified with respect to valve arrangement as follows:

Car	Valve Arrangement
A-1, A-2	Overhead
B	L head
C-1, C-2	L head
D	L head

A new engine was installed at the beginning of each test to reduce to a minimum those variables affected by wear. After a 2000-mile break-in period, combustion-chamber deposits were removed and the engine was assembled and placed on test.

Earlier test work of a similar nature had shown that changes in octane requirement attributable to combustion-chamber deposits could be expected to reach a maximum after 6000 to 8000 miles of operation. To develop the maximum effect, test mileage was extended to 10,000 miles. The tests were arranged in such a manner that each of the three test

Chamber Deposits

EXCERPTS FROM PAPER BY

J. B. Duckworth, Research Department, Standard Oil Co. (Ind.)

• Paper, "Effects of Combustion-Chamber Deposits on Octane Requirement and Engine Power Output," was presented at the SAE Summer Meeting, French Lick, Ind., June 5, 1951. (This paper will be published in full in SAE Quarterly Transactions.)

fuels was used in two cars during any 10,000-mile test period. At the completion of each 10,000 miles of operation, the test fuels were rotated. During the total of 170,000 test miles, each fuel was employed in each car except Car D, in which only two fuels were tested.

The 10,000-mile schedule selected for these tests included an arbitrarily chosen 20% city operation, 50% suburban operation, and 30% intercity operation. This percentage was maintained over each 1000-mile increment to prevent a concentration of any one class of service during the test period. This schedule provided a type of cyclic operation that could be duplicated from test to test and also represented a close approach to actual service operation.

Maximum octane requirements were determined at the start of the test, at 500 miles, at 1000 miles, and at every 1000-mile interval thereafter. The method employed was similar to the commonly accepted CRC method. The increase in octane requirement was determined at the end of the 10,000-mile test period by two methods of evaluation—changes observed over the test period, and before and after deposit removal. Factors other than combustion-chamber deposits that affect octane requirement were eliminated in so far as possible in this work, such as: humidity, altitude, cooling jacket temperature, and ignition timing. Carefully calibrated carburetors and distributors were employed for the determination of octane requirement and power output.

At the end of the 10,000-mile test period, the road octane requirement and the full-throttle power output, as measured on a chassis dynamometer, were determined both before and after deposit removal.

Quantity of Deposits

The weights of deposits removed from the combustion chamber are listed in Table 2. The weight of deposits after 10,000 miles of operation appears to be associated with the presence or absence of tetraethyl lead but does not seem to be directly related to tel content. With the exception of Car D, there is a fair agreement in the amount of deposits for each tel content. On the basis of deposit weight expressed in grams per unit clearance volume, it may be concluded that leaded fuels contribute about twice as much deposits as unleaded fuels.

Effect of Deposits on Octane Requirement

Progressive changes in octane requirement for the three test fuels in Car A-1 are shown in Fig. 1. The curves are typical of the octane requirement buildup for all cars tested under these particular conditions of operation. The most rapid increase occurred during the first 4000 miles of operation for the leaded fuels. The shape of the leaded-fuel curves suggests that a state of equilibrium was reached at roughly 5000 miles. There is some indication that the unleaded fuel had not reached its peak requirement at 10,000 miles, but additional mileage would not have altered the results by a significant amount.

Octane requirements for all cars are summarized in Table 3. These results take into account initial and terminal requirements and, in addition, octane-number requirements after deposits had been re-

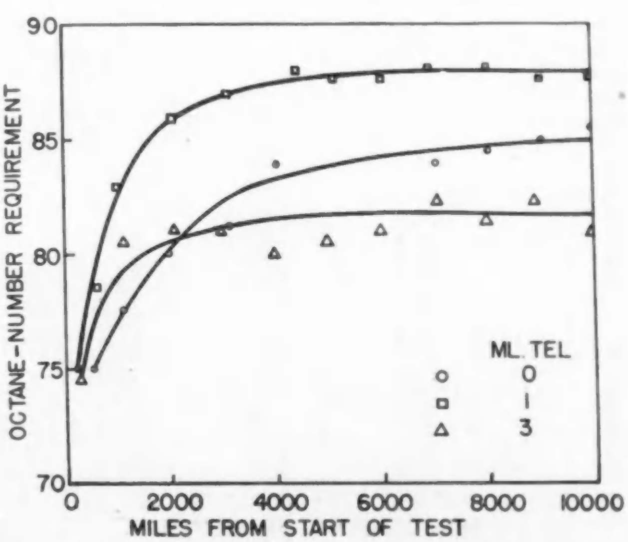

Fig. 1—Change in octane-number requirement with tel content and test mileage

moved from the combustion chamber. For cars of the same make and model, initial octane requirements are in good agreement. By and large, requirements of duplicate cars after 10,000 miles of operation on each of the test fuels are in reasonable agreement. As might be expected, there were considerable differences between cars of different makes.

Average changes in octane requirement are shown in Fig. 2. The results obtained by the two methods agree within one or two units and are within the limits of experimental accuracy. The changes are essentially equal for all three fuels.

The change in octane requirements just noted may be examined more critically in Fig. 3, which shows variations from car to car. The spread indicated by the vertical distance on the chart is about the same at any tel concentration. Further, the random location of car makes on the bar chart indicates that no one make is preferentially susceptible to increase in requirement. The 10-unit difference between Cars A-1 and A-2 at the 3-ml tel concentration is surprisingly great in view of the extreme care exercised to control the tests, and is equal to the difference between cars of different makes on any test fuel. Reasons for the variations are not entirely evident, although subsequent valve refacing tended to reduce them to some extent.

Grouped as a whole, these tests show that, under typical passenger-car service, combustion-chamber deposits may be expected to increase octane requirements by 8 to 12 units, irrespective of the tel content of the fuel. These results are of particular significance to the petroleum industry, for they indicate that octane-number gain afforded by the addition of tetraethyl lead is not nullified by an increase in vehicle octane requirement.

Table 4—Effect of Tel Content on Maximum Torque Output

Tel Content, ml per gal	Torque Change after 10,000 Miles, %		
	0	1	3
Car			
A-1	+5.8	−2.5	−0.8
A-2	+3.3	0.0	+3.4
B	−4.0	−6.6	−9.4
C-1	−3.4	−6.7	+0.9
C-2	−8.3	−5.1	−3.8
D	0.0	−6.0	—

Effect of Deposits on Power Output

Changes in torque accompanying deposit removal are listed in Table 4. The results indicate that the effects of deposits range all the way from a gain in torque of 6% to a loss of more than 9%. Part of these differences may be attributable to differences in combustion-chamber design. In the case of Cars A-1 and A-2, tel content does not appear to be a significant factor with respect to torque change. With respect to Car B, torque loss becomes progressively greater with increasing tel content. These results suggest that torque loss attributable to combustion-chamber deposits is a more important factor with L-head engines than with overhead-valve engines. Incorporation of automatic or torque-responsive transmissions adds to the importance of this problem simply because satisfactory operation of these devices depends upon maintenance of design torque.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

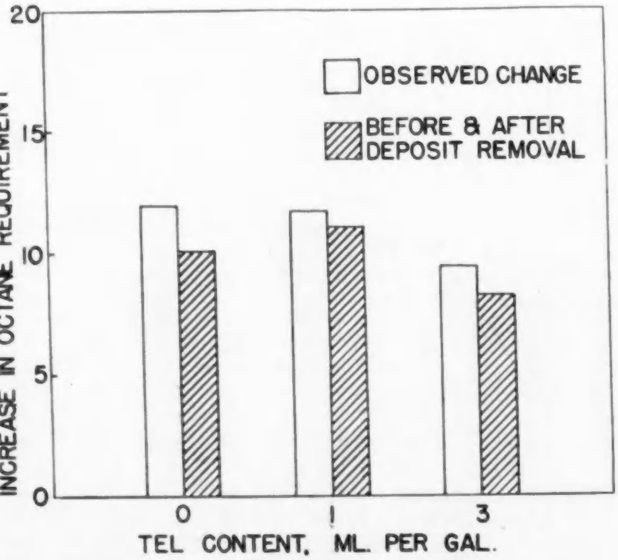

Fig. 2—Increase in octane requirement after 10,000 miles (average of all cars)

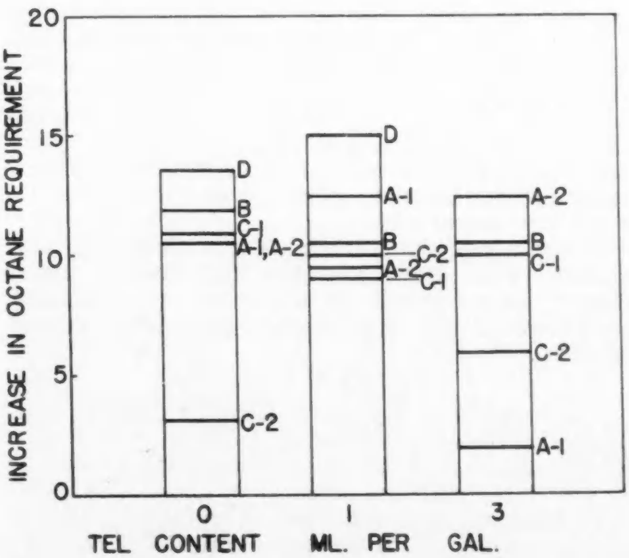

Fig. 3—Increase in octane requirement after 10,000 miles (individual cars)

Question and Answer Forum

REPORTED BY

A. L. Pomeroy, Thompson Products, Inc.

• Question and Answer Forum on Combustion-Chamber Deposits was held at SAE Summer Meeting, French Lick, June 5, 1951, under the auspices of the SAE Fuels and Lubricants Activity. Moderator was A. T. Colwell.

Question: What is the effect of **fuel/air ratio on rate of deposit** accumulation? Is there a noticeable difference between part load (lean mixture) and full load (rich mixture) on rate of deposit formation?

Answer: Regarding the effect of fuel/air ratio on rate of deposit buildup, experience in aircraft operation has shown that cruise operation under lean mixtures did not result in a substantial difference in deposit buildup over rich-mixture operation. All things being equal, it is conceivable that richer mixtures could tend to increase deposits slightly because of the greater quantity of fuel burned. However, this effect could be canceled out by the power changes, combustion temperature variation, and a host of other variables which would generally accompany changes in F/A.

Both laboratory data and road test results show that deposits accumulate at a faster rate under light load as compared to heavy load. In general, vehicles which are driven at high speed have less deposits than those engaged in city-type driving.

Question: How do **deposits on the spark-plug insulator** compare in composition with those found on the other surfaces of the combustion chamber? Do the deposits on the plug insulator flake off as do those on the other surfaces? What are the electrical properties of the various chemical compositions found in the deposits?

Answer: A study of deposits accumulated in a number of engines did indicate that the composition varied somewhat between those in the fuel and those in the hot areas, such as the buildup on the exhaust valve. The effect of these variations has not been definitely established as yet. It is known, however, that the temperature properties of the deposits will differ with changes in composition. The electrical properties of spark-plug insulators will vary with the temperature characteristics of the deposits. However, since the latter cover so great a range, no correlation with temperatures and deposit composition has been established as yet. Flaking off of deposits on the spark-plug insulator has not been noticed.

Question: The papers presented today indicate that as tel content is increased from 1.0 to 3.0 cc per gal, the total weight of chamber deposits or octane increase is not affected; does this same relationship exist in the cases of **plug fouling, valve deposits, and sticking, and accumulation of lead salts in the motor oil?**

Answer: Controlled experimental work on these effects is limited. General experience has shown deposit buildup on plugs and valves generally follows the same pattern as the combustion chamber with regard to tel concentration. It is possible that the higher tel content exerts more influence on the valve performance. With regard to lead salts in the oil, it is safe to generalize that the higher the tel content in the fuel, the more rapid the accumulation. Time between oil drains is an important factor affecting total lead accumulation.

Continued on Next Page ▶

Combustion-Chamber Deposits

Question: Why did the **hydrogen fuel** build up octane increase requirements in the data presented in the prepared discussions?

Answer: Both fuel and oil contribute to deposit buildup, individually and combined. Based on tests using hydrogen as a fuel, it must be concluded that the deposit buildup and the octane requirement increase are chargeable to the lubricant. Gasoline and lubricating oil are predominantly hydrocarbons. It does not appear to make very much difference in the end result whether the deposit binder is contributed by the fuel or by the lubricant.

Question: A figure in one of the papers shows the rate of octane requirement increase after 2000-2500 carbon miles to be less than the initial increase in octane requirement. Is this just effect of **nonlinearity of octane scale?** A given physical effect (change in operating conditions) has greater effect in terms of octane number lower on the octane scale than at higher points.

Answer: It is true that a correction for the nonlinearity of the octane scale could be made. However, this is not a major factor. For example, going from 70 to 71 octane number figures to be an increase of one performance number. From 89 to 90 octane number results in a change of approximately two performance numbers. This would not account entirely for the effect shown in the figure.

Question: With unleaded fuel, the combustion-chamber deposits were less than half those obtained with leaded fuels, yet the **proknock effect** is equal. Since volume effect and thermal effects therefore cannot account for proknock or octane requirement increase, how is it explained?

Answer: First, it should be emphasized that there is a chemical effect of deposits in addition to volume and weight. With regard to the specific question, if the weight basis were converted to volume, the deposit formation would be more closely in agreement with the displaced volume of the chamber.

Question: What effect have **benzol blends** on the flaking action of combustion-chamber deposits?

Answer: Small percentages of benzol have little or no effect on combustion-chamber deposits. Concentrations of benzol in the order of 25% or more could conceivably result in a reduction in deposits because of the lower tel content that would be required. However, this is of academic interest since benzol is not available in these volumes for motor fuels.

Question: If **oil type** can have an important effect on octane-number increase, what will be the effect of extended and wider use of lubricating oils that are more stable and have higher ash content?

Answer: Gasoline engines, as we know them today, do not have a high ash handling capacity. Ash will have some effect on the combustion-chamber deposit problem. However, engines must be properly lubricated and this requirement may subordinate the deposit problem.

Test data from another investigator show that analyses of many deposits disclosed a very small amount of ash from the oil additive. The quantitative effect of these deposits on octane requirement is not known.

Combustion-Chamber Deposits

Question: Has anyone investigated the effect of **injection of water, oil, or any special materials** on removal of deposits? Do "lubricated" gasolines have any beneficial effects on holding down octane requirement increase? Has anyone any data on octane-number requirement increase when using liquefied petroleum gas as fuel?

Answer: It has been well established that water injection will reduce or even eliminate deposits which, in turn, will lower the octane requirement. However, such injection, to be effective, must be continuous and the quantity of water involved is large. This can result in a substantial power loss. Also, injection under light load may cause considerable accumulation of water in the crankcase.

Lubricated gasoline would add to the deposit buildup unless the material used were completely vaporized. With regard to materials for removing deposits, this has been, and still is, the subject of much study. No effective agent has been disclosed as yet.

The liquefied petroleum gas would probably act much the same as hydrogen. Since LPG is high in octane number and generally satisfies the engine through its useful life, little data are available on octane requirement behavior of these fuels.

Question: Has any work been done to check effects of **lime deposits** in the water jacket as thermal insulators? If so, what increase in octane requirement was found?

Answer: The thermal insulating effect of lime deposits in engine cooling jackets has not been studied by us. However, at constant coolant temperature, the addition of thermal resistance in the path of heat flow of the working fluid to the engine coolant would have the effect of increasing combustion-chamber-wall surface temperatures and, therefore, end-gas temperatures.

Any factor that would lead to increasing end-gas temperatures would also tend to increase knock. As far as the end gas is concerned, it makes no difference whether the increase in temperatures is brought about by the addition of thermal resistance or an increase in coolant temperature. One can predict, therefore, that lime deposits on the coolant side of the chamber wall would increase the requirement by decreasing heat rejection to the coolant.

Question: Do you have any information on the effect of **cooling medium temperature** on octane requirement increase? I have in mind comparison of a normal coolant body temperature (160–170 F) versus vapor phase cooling (220–230 F).

Answer: No data are available comparing liquid cooling and vapor cooling, hence, this cannot be answered directly. However, data obtained with water at two temperatures, namely, 140 F and 280 F (pressurized) showed that the octane requirement was a direct function of the coolant temperature.

Continued on Next Page →

Members of the panel of experts that answered the questions were (left to right): J. R. Sabina, E. I. du Pont de Nemours & Co.; J. M. Campbell, General Motors Corp.; W. M. Holaday, Socony-Vacuum Oil Co., Inc.; L. F. Dumont, E. I. du Pont de Nemours & Co.; A. T. Colwell (moderator of the session), Thompson Products, Inc.; H. J. Gibson, Ethyl Corp.; D. P. Barnard, Standard Oil Co. (Ind.); W. E. Drinkard, Chrysler Corp.; J. B. Duckworth, Standard Oil Co. (Ind.). A. L. Pomeroy, Thompson Products, Inc., secretary for the panel, is seated to the rear of the panel members

Combustion-Chamber Deposits

Question: What are the effects of **rate of oil consumption** on deposit growth and increase in octane requirement?

Answer: The rate of oil consumption does influence the rate and quantity of deposit formed. An engine with moderately excessive oil consumption will show a heavy deposit build-up. Single-cylinder tests have shown that a straight-line correlation exists between oil consumption and deposit formation up to the point at which the surfaces become wet from the oil and deposit weight is reduced.

Question: Could one deduce from the data presented in the papers that if the **octane requirement of the engines were greatly increased** (by use of 12/1 compression ratio, say) that the deposit effect on octane requirement would be negligible?

Answer: Our experiments with high-compression-ratio engines do show a trend toward decreased deposit weight at the higher compression ratios. However, engines having compression ratios in the order of 10/1 to 12/1 are sensitive to the influence of combustion-chamber deposit on preignition, so that comparatively small amounts of deposit may produce objectionable preignition. We are far from being out of the woods on this problem.

Question: **Preignition** in many cases seems to be the limiting factor in raising compression ratio rather than detonation. Please discuss effect of types of deposits on preignition.

Answer: Preignition is a very complex phenomenon, which is influenced by many variables. Tendency to preignite is associated with both engine characteristic and fuel composition. Under certain critical conditions of operation, it might be possible to detect some differences on the preignition tendencies of deposit types. At present, however such data are very meager and no generalizations can be drawn.

Question: What relation, if any exists between the **nature of the combustion-chamber surface and deposit accumulation?** More specifically, can deposit buildup be reduced by providing highly polished piston-crown and cylinder-head surfaces or by plating?

Answer: Much experimental work has been done on the polishing and plating of combustion-chamber surfaces. Platings of such metals as copper, tin, cadmium, nickel, chromium, molybdenum, and even gold have been tried and have shown no significant improvement. Perhaps the best answer to this question is that, although this field has been investigated extensively, no process has shown sufficient merit to justify its commercial application. However, efforts are still being expended in this direction and the failures thus far should not be construed to mean that someone will not be successful eventually in developing a plating or coating to which deposits will not adhere.

Question: The **thermal effects** of combustion-chamber deposits have been stated in one of the papers as representing a sizeable percentage of total combustion-chamber deposit effect on octane-number requirement increase. In light of differences in the thermal characteristics of deposits from leaded or nonleaded fuel or even hydrogen, how is the equal increase in requirement increase explained?

Answer: Here again, one must not compare deposits as a whole. Porosity, density, and chemical composition all enter into the influence deposits have on knocking tendencies. Considerable study must be made of the nature of the deposits. While many data have been presented, a large amount of work still remains to be done before the deposits formed by certain fuels can be correlated easily with their influence on octane requirement.

Combustion-Chamber Deposits

Question: We have heard recently of the effect of **boron** on knock. This suggests a pronounced effect of catalysis, yet Mr. Dumont this morning reported that catalysis is relatively unimportant in affecting tendency to knock. What is the panel's opinion? If knock takes place in the end gas, the effect of the surface of the combustion chamber should have no effect, that is, if the end gas is surrounded on all sides by a charge burning normally. In this condition, surfaces would be unimportant in affecting knock. What does the panel think of this factor and its importance? Please define the conditions leading to detonation in a hydrocarbon-air mixture that begins burning in a normal manner.

Answer: Some work has been done with boron to study its effect on combustion-chamber deposits and octane requirement. These data have not been released as yet. From a preliminary study however, it appears that the results on boron are open to interpretation and, therefore, until more data are available, no definite statements can be made.

Knock does take place in the end-gas zone. The surface of the combustion chamber can have an effect for it can influence the temperature and, if deposits are present, they can also have catalytic effects. Many theories are propounded on the mechanics of detonation and its supression. It is sufficient to say that there is a critical temperature, pressure, and time constant that promote detonation. This factor varies for engines and fuel composition.

Question: Have test results indicated any factors in combustion-chamber design that tend to promote **sloughing of accumulated deposits?** No mention was made of the proknock characteristics of deposits as related to their geographic disposition in the combustion chamber or related parts, such as spark plugs and valves. Please amplify. It was brought out that physical and chemical character of deposits was in part related to chemical composition of fuel and tel content. Would alternate use of fuels of different character (that is, a regular and a premium fuel) result in some stratification of deposits and increased response to removal by thermal shock in flexible operation?

Answer: The sloughing off or flaking of deposits is dependent on many factors. Thermal shock is very effective in deposit flaking. The combustion-chamber design can retard the sloughing off of deposits by providing surfaces to which deposits can adhere and will impart physical strength to the deposits.

As mentioned previously, the effect of geographic location of the deposits is exceedingly difficult to determine. In general, it is believed that deposits formed in the piston-dome area have a more harmful effect with regard to octane requirement increase.

Very definitely, fuel composition influences the physical and chemical character of the deposits. However, the change from regular to premium fuel is not enough to bring about a substantial difference in the deposits. The only change would be the physical shock of detonation should the engine be adjusted to be on the threshold of knock with a premium fuel and then operated on regular gasoline of lower octane.

Question: What can be done to promote **flaking** of engine deposits? Discuss particularly possible chemical additives for promoting flaking. What is the contribution to engine deposits of metallic additives in heavy-duty oils? To What extent do these deposits affect octane demands?

Answer: Considerable work is being done by the petroleum industry and marketers of tel in developing additives which will promote flaking. However, because of proprietary considerations, the latest data cannot be disclosed at present.

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Combustion-Chamber Deposits

Question: Mr. Dumont showed that the weight of combustion chamber deposits for 3 ml of tel was less than that for the 1.5-ml fuel. One possible explanation for this fact is that the scavenging action of the **halogen cleanup agents** is dependent on the *amount* used and not on the ratio of halogens to tel. I appreciate that other considerations than combustion-chamber deposits must be accounted for, but I would like to know if there are any data that show the effect of using the 3-ml tel level of halogen in the 1.5-ml tel per gal concentration?

Answer: Data obtained thus far show that the balancing of the scavenging agents is very involved. Valve life, operating conditions, and composition of the fuel all influence the effect of deposit scavenging. Increasing the ratio of the halogen does not necessarily result in more effective scavenging. Under certain constant conditions, it may be possible to get a more effective ratio of scavenger to tel. However, this ratio could be a poor compromise for the operating range of the engine.

Question: Is there an explanation for the relatively small increase in octane requirement in the tests at **constantly knocking operation** in spite of the appreciable deposit accumulation?

Answer: Although deposit accumulations were reduced about 25% under continuous knock conditions, this reduction could not account for the decrease in deposit knocking harm from 22 to 2 units. X-ray diffractions and chemical analyses indicated that the deposits formed under knocking and nonknocking conditions were chemically almost identical. The principal difference between these deposits was that those formed under continuous knocking conditions appeared to be substantially less porous than those laid down under nonknocking or intermittent knocking conditions. This suggested that the reduction in deposit knocking harm was brought about by the formation of a more dense deposit, which would tend to have a lower thermal insulating effect.

Question: Is the antiknock action of **lead chloride** considered to be catalytic in effect? If so, please explain the mechanism of its antiknock action. What is the reason that 3 cc tel per gal has a smaller effect than 1.5 cc per gal on the increase in octane requirement? Does lead concentration have a similar effect on spark-plug behavior? How do you explain V. G. Raviolo's observation that the position of the deposits in the combustion chamber is most important in determining the effects of deposits upon rise in octane requirements?

Answer: The antiknock mechanism of lead chloride dust is not known, as indicated earlier. However, it is apparently not the result of its end-gas cooling effect or its effect on the mass rate of burning. If the antiknock mechanism should result in a catalytic destruction of molecular species leading to knock, then decreasing the dust particle size would tend to promote these reactions, due to an increase in the particle temperatures and, also, an increase in dust surface area.

With regard to the second part of the question, the data reported showed that varying the tetraethyl lead content of the fuels from 0 to 3.0 ml per gal had no effect on octane requirement increase, despite the fact that both the weight and chemical composition of the combustion-chamber deposits formed was changed drastically.

There is considerable difference of opinion regarding the effect of the location of deposits in the combustion chamber on octane requirement increase. There are some data which show that location of deposit will influence power output. In an L-head engine, it was found that one gram of deposit on the dome area was twice as effective in reducing power as the same weight of, or amount of, deposit in some other location. Because of the many variables involved, the location of deposit with octane requirement increase is difficult to correlate. Limited data from L-head engines indicate that deposits on the dome of the piston and on the head over the piston are probably most harmful with respect to octane requirement increase.

Combustion-Chamber Deposits

Question: Preignition effects. Certain deposits in an engine appear to cause very definite preignition with no indication of detonation, as observed in an oscilloscope, when using cumene as a fuel. What, if any, is the relation between type of deposits and preignition? (No mention has been made of differentiation between detonation and preignition.)

Fig. 12 of Mr. Dumont's paper. This is a very interesting relation, which may have tremendous importance. In this case, the particle size is doubled, which means there will be one-eighth the number of particles and one-fourth the surface area. Thus, roughly twice the weight of material is required for the same octane requirement. This ties in with work we have done at Purdue, which showed that, in continuous process combustion, the expression for heat required for initiating combustion is "Btu per square ft per unit time." If this applies to Fig. 12, it will be seen that the reduction in octane requirement may be related to the ignition of the *last portion* of the charge rather than avoidance of ignition by cooling the end charge. Please comment on this relationship.

Answer: Preignition can be defined as an ignition of fuel-air charge in advance of spark-plug firing. Detonation is the result of a compression-ignition, that is, the charge has been fired by the plug and combustion is progressing normally when, suddenly, the end gas (unburned portion) is ignited with a violent pressure rise. Preignition can be caused by incandescent deposits igniting the mixture prematurely and having the same effect as advancing the spark timing. Detonation is not caused by incandescent deposits.

Cumene was used as a component of aviation fuel during World War II. In this service, no preignition difficulties were encountered, although spark-plug fouling appeared to be aggravated. Xylidine was also used in small quantities and, with this compound, a tendency toward preignition was noted.

It has been found that lead chloride apparently does not function as an antiknock agent by acting as an internal coolant. Experiments have indicated those dusts which have the greatest cooling capacities are not necessarily those which also have the greatest antiknock effect. It is true that decreasing the particle size of the dust has the effect of increasing the temperature of the particles which could provide centers for ignition in the unburned portion of the fuel, however, data obtained in an F-4 engine indicate that the *overall* mass burning rate of the charge is not influenced by the presence of lead chloride dust, even though the octane requirement is substantially reduced.

Question: It has been pointed out that deposit accumulation has a definite effect on decreasing air consumption with increase in hours of operation. Is there additional information in these same engines on (1) effect on **horsepower output**, (2) effect on **fuel consumption** over the same period? How did tel content affect exhaust valve life in the road tests reported on? Were there any failures in these relatively short miles of operation due to deposits?

Answer: In the particular tests reported, brake horsepower measurements were made and it was found that the loss in brake horsepower was approximately proportional to the losses in air consumption. These experiments were conducted at constant air/fuel ratio and, therefore, the total fuel consumption decreased in direct proportion to the decrease in air consumption.

Other panel members believe that the deposits not only affect airflow but, also, thermal efficiency. It is the opinion that tel exerts a greater influence on power loss and specific fuel consumption than on knock. This same investigator stated that spark advance will vary with deposits. As the engines become dirty, less advance is required. It appears that the effect of types of deposits on thermal efficiency will warrant further investigation.

There was no exhaust-valve failure during the course of the road tests. The type of operation and the mileage accumulated cannot be considered as a test for deposit influence on valve life.

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Combustion-Chamber Deposits

Question: Does anyone have any information they would be willing to quote on the effect of **lubricating oil type** and **additive content** on octane requirement increase? The general conclusion appears to be gaining favor that tel does not contribute to octane requirement increase. Does anyone have any information that differs with this? Does anyone have any further information on the catalytic effect of deposits on octane requirements?

Answer: While much data have been obtained on the factors which influence octane requirement, the surface has just been scratched. One consistent trend is indicated, namely, that tel content has a negligible effect on octane requirement increase. The type of oil used does have an effect on octane requirement increase but, here again, this is influenced by the composition of the fuel and the operating conditions. While there is not much difference in effects shown by modern high VI oils, test data indicate it may be possible to influence requirement increase to a significant degree by changes in oil composition. In tests of heavy-duty oils, the additive content did not seem to affect the octane requirement increase. Generally speaking, high additive oils may reduce deposit weight, but not deposit volume. The use of these oils has indicated a reduction of lead in the deposit with the substitution of compounds of the lighter metals from the lubricating oil additives.

Question: Is there a correction upward for the **throttling effect** of the heated deposits in reducing octane requirements made in the data presented? Does the knock-free power reflect the airflow loss in the same magnitude and general relationship as the octane requirement in the laboratory test data in all cases where measured?

Do you not believe that the change in air pattern in the cylinder head introduced by the washers described in Mr. Hall's discussion caused as great a variation as the heat condenser effect?

Answer: The octane requirement data presented have not been corrected for the loss in air consumption. The loss of brake horsepower in these tests was found to be approximately proportional to the loss in air consumption.

In both cases, the mass of the washers was the same. It is not believed that separating the washers influenced the air pattern to an extent whereby the octane requirement was involved. It is believed that this increase in requirement was very definitely due to the increased rate of heat transfer because of the greater surface area exposed.

In the general discussion following the formal question-and-answer phase of the program, additional items of interest were brought out. One investigator emphasized that the influence of deposits on octane requirement takes place rather rapidly at first and then decreases. In the work being disccssed, it was reported that in the first 1000 miles of operation, the octane requirement increased from one-half to one-third of the total rise recorded in 10,000 miles. This may indicate a subject for additional study.

The desirability of developing materials that can be put into the oil or fuel, or both, to eliminate deposits was emphasized. This, of course, represents an ideal objective and is the ultimate goal in the deposit problem. Studies are under way to determine the effect of flame speed on deposit formation. Many investigators are applying much research in the analysis of the fuel and oil components which produce the binders in chamber deposits.

It was agreed that the data presented at these sessions represent very extensive effort which has been applied to a very complex problem. Fundamental studies of this nature will go a long way toward effecting practical solutions for combustion-chamber deposits. It was brought out that considerable work is still under way, and it was evident that all involved are cooperating to bring practical solutions as soon as possible.

SOIL KNOWLEDGE

Can Prove Useful to Designers

EXCERPTS FROM PAPER BY

William S. Pollard, Jr., Civil Engineering Department, University of Illinois

• Paper, "Soil Properties and the Design of Earthmoving Equipment," was presented on April 10, 1951 at The Earthmoving Industry Conference, Peoria, Illinois.

APPLICATION of the broad principles of soil mechanics to earth resistance problems can prove useful in designing better earthmoving equipment. Users demand that equipment do an adequate job in all soils, consequently, design procedures should not be based on the charactertics of a particular soil. An understanding of the fundamental properties of soils by equipment designers thus becomes necessary to insure that required compromises will be made efficiently and intelligently.

Knowledge of soil textures and descriptive names, soil strength properties, and soil failure is essential to an understanding of soil behavior.

Soils

Soils are composed of mineral and/or organic particles ranging in size from colloids to particles several inches in diameter. For purposes of identification, certain size ranges have been established. (See Fig. 1.)

A mass of soil has certain properties natural to it by virtue of its grain size and shape, density, gradation, moisture content, and mineralogical composition. The strength of a given soil is primarily determined by the combined effect of cohesion and internal friction, which two properties determine the shearing resistance.

Internal friction is the resistance of the soil grains to sliding and rolling across each other. It is a phenomenon of mechanical resistance to movement on the part of the soil grains. Gravels and sands have high values of internal friction while silts and clays normally have low values.

Cohesion is the shearing resistance of a soil in the absence of normal load perpendicular to the plane of failure. It is a force attributable to the attraction of the soil grains for each other in the presence of moisture, the force increasing with decreasing moisture content. Cohesion is highest in clays, and is of little or no significance in sands and gravels. In magnitude, it may range from as much as 2000 lb per sq ft for stiff clays to zero for wet silts or dry sands and gravels.

The majority of soils encountered are not pure gravel, sand, silt, or clay, but are usually composed of two or more of these soil fractions. Therefore, it becomes necessary to determine the relationship between shearing strength, cohesion, and internal friction. If a soil possessing both cohesion and internal friction were tested in a shear box under different normal loads, the shear failure values would plot as shown in Fig. 2. (For purposes of simplification, all forces have been reduced to stress.) The equation of the failure line is

$$s = c + p \tan \Phi, \qquad (1)$$

where s is the shearing resistance of the soil in lb per sq in., c is the cohesion of the soil in lb per sq in., p is the normal pressure in lb per sq in., and Φ is the angle of internal friction in deg.

For the case of a cohesionless soil, the value of c is zero and the equation becomes

$$s = p \tan \Phi$$

Certain clay soils, when saturated, derive all of their strength from cohesion, in which case equation (1) reduces to

$$s = c$$

The moisture content of a given soil may have a pronounced effect upon the strength of that soil. The effect of changes in moisture content is quite different for different soils. For instance, a fairly stable silty clay material may be reduced to the state of mud having practically no supporting power by the addition of water. On the other hand, confined gravels and sands are little affected by extreme changes in moisture content. For soils other than sands and gravels, the load-carrying capacity is at a maximum when their moisture content is at or below the shrinkage limit. (Moisture content is expressed as a per cent of the oven-dry weight of

Material	Grain Size, mm	Descriptive Terms
Gravel	above 2	Granular, Coarse-Grained, Non-Plastic, Non-Cohesive
Sand	2 to 0.05	
Silt	0.05 to 0.005	Non-Granular, Fine-Grained, Plastic, Cohesive
Clay	0.005 to 0.001	
Colloids	below 0.001	

Fig. 1—Soil fractions

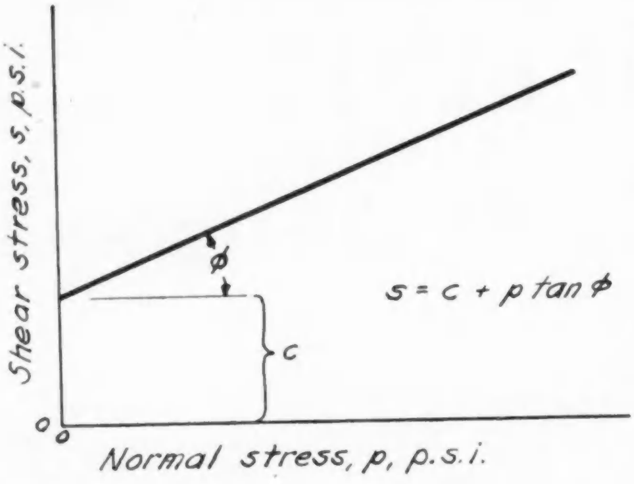

Fig. 2—Shear test on typical soil

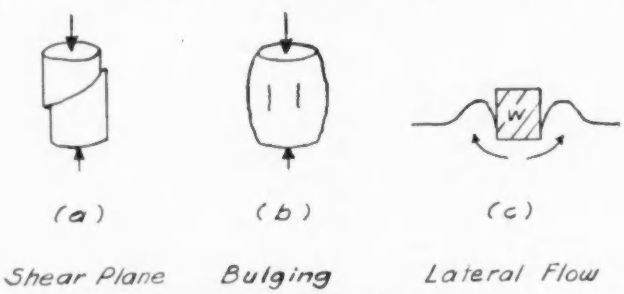

Fig. 3—Some types of soil failure

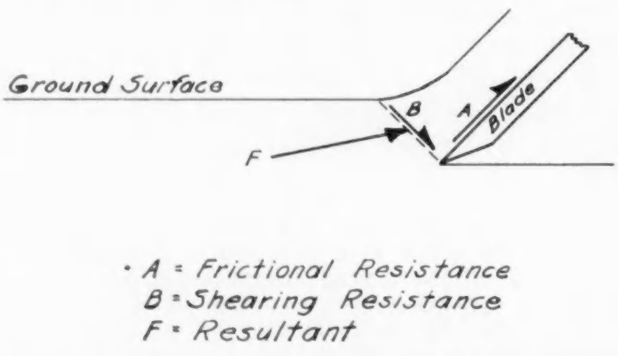

Fig. 4—Analysis of earth resistance forces that must be overcome in a cutting operation

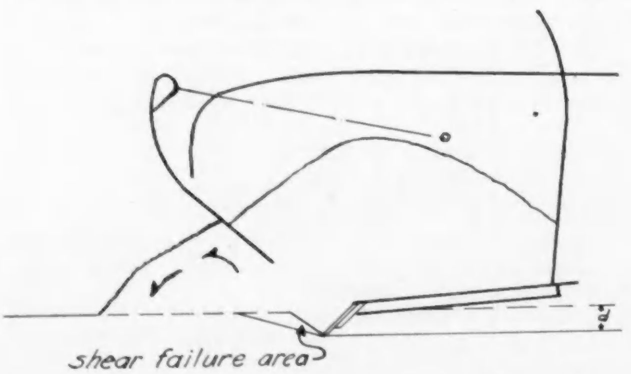

Fig. 5—Condition of refusal of a scraper to load in sand

the soil.) The shrinkage limit of a soil is defined as the moisture content at which the soil ceases to shrink.

Inspection of equation (1) leads to two significant conclusions:

1. Surcharging an area of soil dependent upon internal friction for its strength appreciably increases its shearing resistance.

2. Surcharging an area of soil dependent upon cohesion for its strength has little effect upon its shearing resistance.

Soil will generally fail in one of the three shear failure patterns illustrated in Fig. 3. When soils are ideally workable from the standpoint of moisture content, the failure pattern is usually either of the distinct shear plane type or of the bulging shear type.

In the case of many cutting operations such as those of dozer blades or of scraper blades, certain cohesive soils, having been cut, will act as short columns capable of sustaining load. The type of failure is one of flexure, the flexure being induced by: (1) side thrust from the previously loaded soil through which the column must pass, (2) longitudinal loads on the column, or (3) forced bending of the column as by a curved dozer blade. Failure normally occurs when the cohesive strength of the soil has been overcome, cohesion here representing the tensile strength of the soil.

Design Considerations

Many items of earthmoving equipment use a cutting blade. An analysis of the earth resistance forces that must be overcome in the cutting operation of such a blade is shown in Fig. 4. The forces consist of frictional resistance to sliding of the earth along the steel cutting blade, and shearing resistance along some shear failure plane through the soil. When combined, these two forces represent the resistance of the soil to being cut. The magnitude and direction of the resultant force, F, are items of significance. An inspection of the equation set up for F reveals that: (1) earth resistance varies directly with the depth of cut, and (2) the value of F is a minimum when the blade angle is 0 deg and a maximum when the angle is 90 deg.

Application of the principles of soil mechanics to the earth resistance problems of scrapers can prove fruitful. Loading resistance in a scraper is principally dependent upon the weight and nature of the material in the scraper bowl. Refusal to load occurs when the entering column of soil has insufficient strength to force its way up into the bowl. When this state of refusal is reached, the soil being worked normally piles up ahead of the cutting edge.

Refusal in Sand:

Fig. 5 illustrates the condition of refusal of a scraper to load in sand. An examination of conditions maintaining at refusal in the vicinity of the cutting edge reveals that:

1. There are two paths that the sand may take, being:
   (a) enter the scraper bowl, and
   (b) roll ahead of the apron.

2. When the load in the scraper has reached a certain magnitude, the column strength of the sand

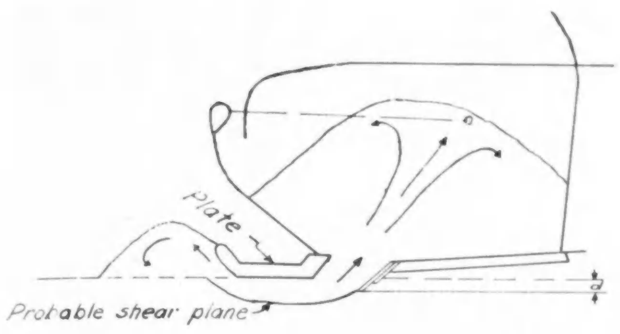

Fig. 6—Confining plate suggested for better scraper loading in sand

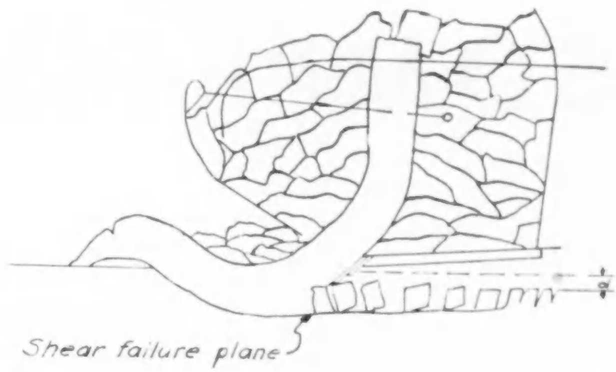

Fig. 7—Condition of refusal of a scraper to load in cohesive soil

is insufficient to overcome the weight of sand above the bowl entrance.

3. This condition of failure is a continuation of normal shear failure ahead of the blade plus a refusal of the cut material to enter the scraper bowl. The probable plane of shear failure is as indicated on the sketch.

4. A method of effecting additional loading is to increase the column strength of the sand.

Fig. 6 shows an attachment suggested by the above considerations. This "confining plate" should extend the full width of the cutting edge and be connected to the bowl by structural members at the ends of the plate. It should be easy to attach and remove, and should have alternate bolt holes to permit adjusting the clearance between the plate and the cutting edge. Consideration of Fig. 6 leads to the following observations:

1. The weight of the loaded bow contributes a confining force through the plate to the sand.

2. This confining force on the sand is roughly normal to the line of shear failure at refusal, increasing the resistance of the sand to failure in shear below the plate.

3. The plate increases the length of the refusal shear failure plane, contributing to the formation of additional area to resist failure in shear.

4. This increased resistance to failure in shear at refusal should increase the column strength of the sand being forced into the bowl, and should permit additional loading without resort to pumping.

5. The load coming onto the confining plate is, or could be made to be, a function of the load in the bowl of the scraper. As the load in the scraper increases, the confining force increases, giving a correspondingly greater column strength to the sand attempting to enter the bowl.

Refusal in Cohesive Soils:

Cohesive, clayey soils are capable of developing considerable column strength. This column strength permits, in the ideal situation, a column of cut soil to travel with moderate resistance through material already in the scraper bowl. At refusal, a cohesive material would probably exhibit a failure pattern as shown in Fig. 7. A study of Fig. 7 indicates that:

1. The total frictional resistance of the material in the scraper against the earth column is greater than the total shearing resistance of the soil ahead of the cutting edge.

2. The soil, being of a cohesive nature, derives but little of its strength from internal friction. Loading or surcharging the area of failure would not, therefore, result in any noticeable increase in shearing resistance.

3. The power demand of the scraper increases greatly as the bowl fills.

4. An indicated item of possible consequence is

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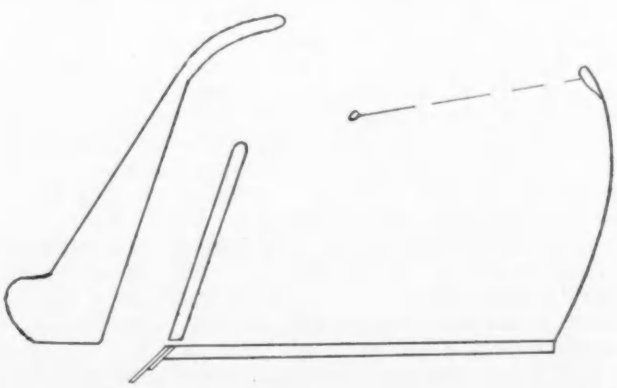


Fig. 8—Entering soil does not have to "buck" previously loaded material with this suggested scraper design

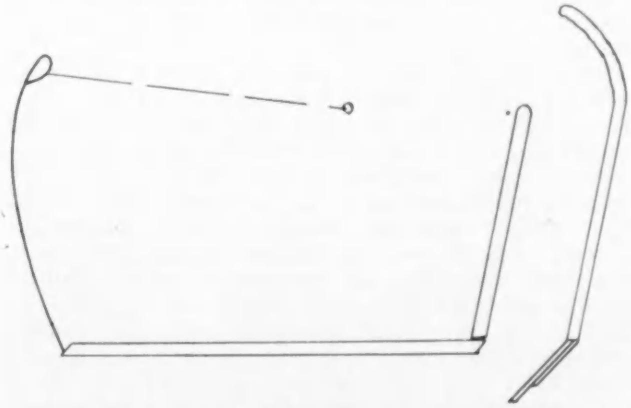


Fig. 9—Cradle mounting of this suggested scraper permits large boulders to be loaded from the front

COMPRESSOR SURGE

NACA investigation of compressor surge problems has led to these principal conclusions:

1. The compressor surges as a unit with the flow pulsating at the same frequency throughout.

2. Stall of any given stage in an axial-flow compressor is not a sufficient condition for surge; because a positive slope appears to be a definite criterion for instability, the increase in the algebraic value of the operating slope of any stage is to be avoided.

3. Surging may actually be only one of many undesirable manifestations resulting from attempt to operate a compressor beyond the envelope line of its potential performance curve.

4. A universal cure-all for surging does not exist at the present time, but ingenious application of the fundamental knowledge now available should permit definite improvements to be made in the off-design operation of any given compressor.

Compressor surge is an unstable flow condition characterized by pulsations of the flow that, besides causing appreciable power reduction, have in some cases caused engine failures. Engine operation in this region is not permissible, and means must be found to avoid such unstable operation.

Because comparatively low compressor pressure ratios have been used up to the present time, it has been possible to avoid engine operation near the surge region by matching the compressor and the turbine in such a manner that the distance between the engine operating point and the surge point is safe.

However, for over-all pressure ratios in excess of 7 or 8, it appears that this method of circumventing the surge problem becomes impractical, as can be seen from Fig. 1. Here are presented typical high-pressure-ratio compressor performance characteristic curves of pressure ratio against percent of design weight flow for various percent compressor speeds. Also shown are lines of constant efficiency, the surge limit line, and the desired operating line of the compressor in the engine. It is apparent that stable operation along this operating line is impossible because the surge limit occurs at higher flows than the desired engine air flows. For such high-pressure-ratio compressors as this one, changing the matching between compressor and turbine enough to avoid surge would effectively mean that at the design speed the operating line would be shifted to lower percentages of pressure ratios but to appreciably lower efficiencies. Furthermore, for high-pressure-ratio compressors, it becomes increasingly difficult to alter the compressor performance to improve the matching over the necessary range of speeds. For example, a method that has been frequently used is to add another stage to the compressor in order to increase the pressure ratio over the whole speed range. In a high-pressure-ratio compressor, however, the exit stages are turbining or are close to turbining at the low speeds so that the addition of another stage might reduce the pressure ratio in the critical speed range even further.

The early experimental investigations conducted by the NACA on surging of aircraft superchargers were aimed at determining the flow conditions through the machine during surge and determining how the operating and setup conditions affected the surging characteristics. The investigations were conducted in a compressor test stand in which the supercharger was driven by an aircraft engine or a dynamometer with a step-up gearbox to give the desired compressor speed. The air flow and pressure ratio were controlled by throttle valves in the inlet and outlet air supply piping.

A pressure-sensitive diaphragm having a high natural frequency was used to measure the pressure and velocity pulsations during surging. One side of the diaphragm was connected to the pressure sensing device (either a static-pressure wall tap or total-pressure tube, whichever was of interest) and the other side was connected to a fixed pressure. Velocity pulsations were measured by connecting a static-pressure tap to one side of the diaphragm and a total-pressure tube to the other. The deflection of the diaphragm was transmitted by a light beam to a motor driven roll of film so that an instantaneous record of the pulsations was obtained. Total-, static-, and velocity-pressure variations were measured in the inlet and outlet ducts for three centrifugal-type superchargers. Data were obtained for various speeds and lengths of inlet and outlet ducting. Static-pressure variations were more recently measured in each stage of a multistage axial-flow compressor as the unit was operated into and out of surge.

Fig. 2 represents an instantaneous photographic record of the outlet total pressure obtained for a fully shrouded supercharger impeller. For this particular run, the impeller was operated at a con-

Investigated by NACA

EXCERPTS FROM PAPER BY

R. O. Bullock and H. B. Finger, Lewis Flight Propulsion Laboratory, NACA

• Paper, "Surging in Centrifugal and Axial Flow Compressors" was presented at SAE National Aeronautic Meeting, New York, April 16, 1951.

stant speed and the outlet throttle was gradually closed until audible surge occurred. At point A on the trace, only small fluctuations in pressure exist. Point B shows the existence of small periodic fluctuations that persist as the throttle is closed until at point C large intermittent audible fluctuations appear. At point D the fluctuations become periodic. Upon gradually opening the outlet throttle, it was found that the sequence of events was reversed. However, it was necessary to open the throttle beyond the point at which surge began in order to stop surge. This "hysteresis" effect has since been noted in practically all of our centrifugal and axial-flow compressors. Although the results shown in Fig. 2 were obtained for a fully shrouded impeller in combination with a vaned diffuser, they are representative of all the compressor surge traces obtained.

Although this compressor had only one unstable region, some centrifugal and axial-flow units have indicated unstable operation at higher flows than the surge region which terminated the operating range at low volume flows. An example of such a

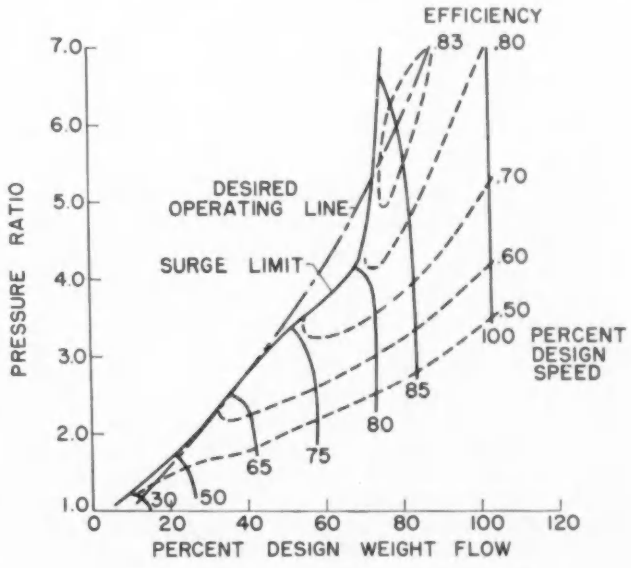


Fig. 1—Performance of high-pressure-ratio axial-flow compressor

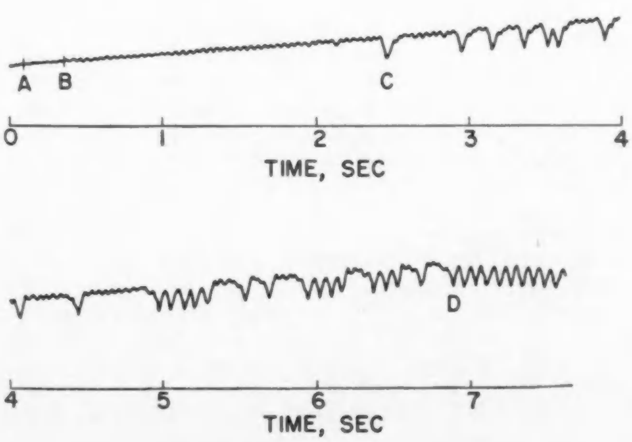


Fig. 2—Outlet total-pressure traces

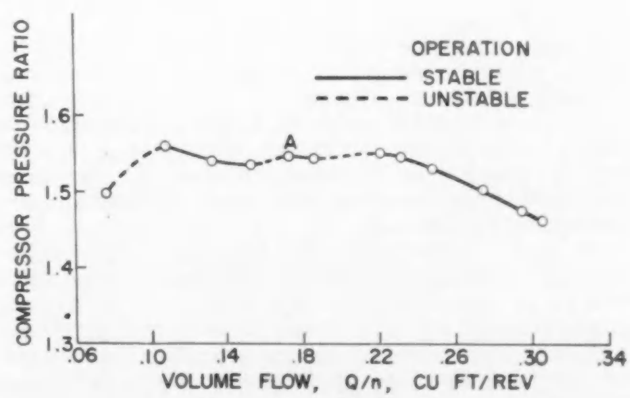


Fig. 3—Mixed-flow compressor performance at 900 fps tip speed

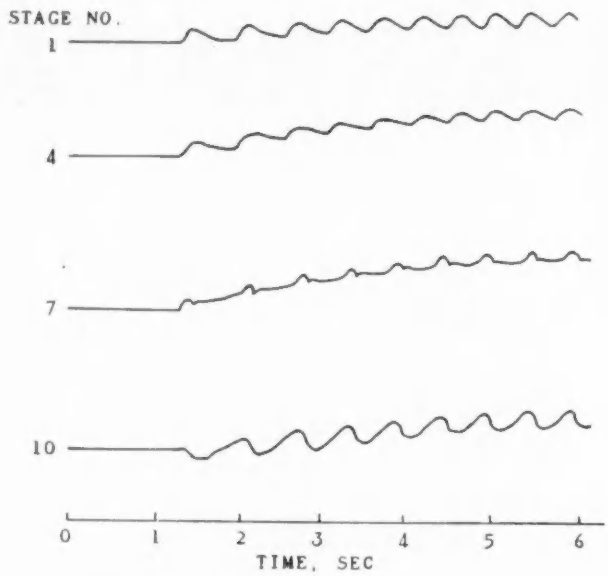


Fig. 4—Entering surge

performance curve obtained on a mixed-flow impeller is shown in Fig. 3, where pressure ratio is plotted against the ratio of volume flow to compressor speed. The dotted-curve portions indicate unstable operation. The traces of pressure fluctuations obtained by use of the instantaneous pressure recorder indicated that the magnitudes, frequencies, and configuration of the pulsations were different for each of these unstable ranges. In fact, the pulsations at region A were inaudible and could be detected only by use of the pressure diaphragm. An important point observed in all these supercharger tests was that the instability always occurred in a region of positive slope of the characteristic curve, a condition which can be shown to have inherently unstable trends.

In investigations of the effect of external duct volume on surge characteristics of a conventional radial-flow impeller in combination with a vaneless diffuser and a scroll collector designed to keep the volume enclosed in the unit to a minimum, it was found that a large external volume gave low-frequency, high-amplitude pulsations; whereas, a small volume resulted in high-frequency, low-amplitude pulsations. These results agreed with the earlier results of Brooke in England. In spite of the change in the pulsation characteristics with change in external volume, any change in the flow at which surge occurred was small and within experimental accuracy.

Using the pressure-sensitive type of instrumentation, an investigation was conducted to determine the surge characteristics of a multistage axial-flow compressor designed for use in a jet engine. In general, the results of the supercharger investigations appeared to be applicable to the axial-flow-compressor surge phenomenon. Fig. 4 shows the static-pressure fluctuation traces obtained in four of the stages at design speed as the compressor entered surge. The traces follow essentially the same trends as the supercharger traces although the shapes of the individual curves differ from one stage to another. The fact that all the stages start surging at the same time and the fact that the frequency of pulsation is the same throughout the compressor indicate that surge is a function of the over-all performance of the unit (just as in the case of the centrifugal machines).

Analysis of results of these and other preliminary investigations has led to certain tentative conclusions as to the surge characteristics in both centrifugal and axial-flow compressors:

1. The compressor surges as a unit, which suggests a flow instability determined by the over-all performance of the compressor.

2. The surge region actually falls in a range of positive slope although the point at which surge starts may appear to be on a negative slope or at the peak of the charateristic curve.

One may wonder whether there exists a useful operating region at lower weight flows and at possibly higher pressure ratios that could be used if surging could be circumvented. In order to answer this question, numerous attempts have been made to pentrate the barrier of the surge line.

With three compressors, NACA was able to obtain stable operation beyond the normal surge point. (Surge barrier of a fourth compressor could not be penetrated.) In one of the experiments beyond the surge point, a portion of the air at the outlet of a mixed-flow compressor was recirculated into the inlet in such a manner that rotation was imparted to the inlet air stream. When the normal surge point was reached (points A, Fig. 5), the recirculation system was put into operation and the surging was suppressed. After closing the throttle slightly, it was possible to close the recirculation system completely, and observe stable flow until

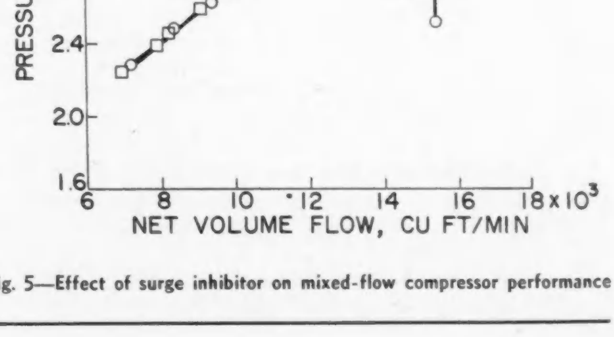


Fig. 5—Effect of surge inhibitor on mixed-flow compressor performance

the points B were reached. Beyond these points, it was always necessary to utilize recirculation to obtain surge-free operation.

The interpretation of these results required the knowledge of two important facts:

1. The slope of the performance curves at the first surge point was infinite, indicating that choked flow followed by a normal shock existed somewhere within the compressor.

2. Flow relative to the leading edge of the compressor blades was supersonic over the outer half of the annulus, a condition that would cause an array of strong shocks to appear near the leading edges of the blades.

During operation below points A, it is believed that the air entering the impeller first suffered a loss in relative total pressure while flowing through the inlet shock-wave system, then was reaccelerated to the relative speed of sound at the choked region, and then suffered another loss in relative total pressure while passing through the second shock. Closing the throttle brought the second shock closer and closer to the region of minimum area until it was expelled at points A. The slope of the performance curves is thus infinitely negative up to A, where it normally becomes almost infinitely positive.

Part of the action of the recirculating system was apparently that of redistributing the flow at the inlet so that the shock waves near the leading edge would either be reduced or contained, permittin the air to flow with less loss in relative total pressure in this region. Just above points A, the flow is thus readjusted and the normal shock is again downstream of the choked region; the higher total pressure reflects the decrease in losses at the inlet. Beyond points B, a rapid change in slope is observed.

This and similar results show that when surging is instigated by a shock wave being expelled from a position within the compressor blades, regions of higher pressure ratio and possibly lower weight flows may be potentially available. Essentially, such a compressor has several surge points, each of which may be characterized by local regions in which the characteristic curve has positive slopes.

A different result was observed when the NACA 8-stage compressor was operated with a 2-stage turbine for an experimental jet engine. The unyielding surge line obtained during bench tests of this compressor was found to be non-existent on the jet engine. Instead of encountering pressure and velocity fluctuations at the surge line, the performance of the engine simply deteriorated to an inferior operating point. A presentation of the compressor data in conventional form is given in Fig. 6. No data were obtained in the dotted regions of the curves because there was no real point of compressor-turbine operation in that region. One may venture a strong opinion, however, that the pressure ratio of the compressor must fall rapidly as the air flow is even very slightly decreased from the peak pressure-ratio points on the curves.

Our experiences with these three compressors show that there are good reasons for believing that the surge point is practically coincident with a point where the pressure ratio begins to fall as the weight flow is reduced or as the throttling is increased. When surging results from expulsion of a shock, further increases in throttling may or may not cause the pressure ratio to increase again through a readjustment of the flow in the compressor. When surging does not result from shock expulsion, one may expect that, potentially, a rapid deterioration in performance results from increasing the throttling beyond the observed surge point; that is, the curves of Fig. 6 will be the rule rather than the exception.

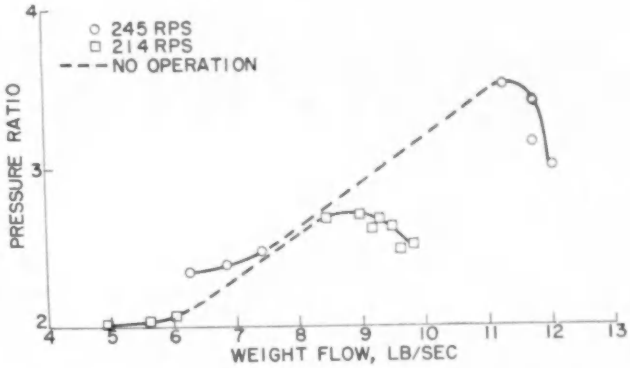


Fig. 6—Compressor pressure ratio versus inlet flow for eight-stage compressor

Other Deleterious Effects

If one accepts the thesis that the slope of the performance curve is positive immediately to the left of the surge point, he is immediately confronted with the fact that surging may be nothing more than one manifestation of a more fundamental problem—the impossibility of obtaining any kind of operation beyond an envelope line. An envelope line drawn over the useful portion of the performance curves would in general differ so little from the surge line that the two curves are practically coincidental. Any points above and to the left of the envelope line are either non-existent or of such low efficiency that they are practically useless. Any point of the engine operating line passing through the left of the envelope line would be inaccessible. In most cases, attempts to approach such points culminate in surge. If the compressor did not surge, however, something equally undesirable would probably occur. The engine performance may deteriorate; turbine inlet temperatures might rise to intolerable values; or combustion itself might be rendered unstable. The problem, then, is not so much that of avoiding surging, but that of preventing excessive positive slopes of the performance curves.

(Paper on which this abridgment is based contains also a section on improvement of off-design performance characteristics. Complete paper is available in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

COMPRESSOR SURGE

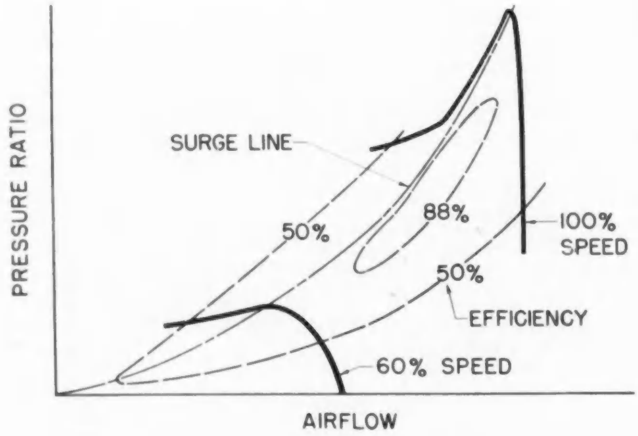


Fig. 1—Typical performance curve of an axial-flow compressor

COMPRESSOR surge was defined as an instability of the airflow, often violent, which terminates the operating range of compressors at reduced flow. A typical performance curve of an axial flow compressor is shown in Fig. 1, where pressure ratio is plotted against airflow at constant rotor speeds. Regions of high efficiency are indicated by contours on this plot, and the surge line is here interpreted as the locus of peak pressure ratio points at each speed, although discussion brought out a good many variations from this. Experimental data may be obtained, with difficulty, to the left of this line on a compressor test, but an engine is usually inoperative in this region due either to flow instability or inefficiency of compression.

The relationship between the surge line and the demands of engine operation was brought out in a series of curves, an example of which is shown in Fig. 2. The power output of the turbine is matched to the power required to drive the compressor, the

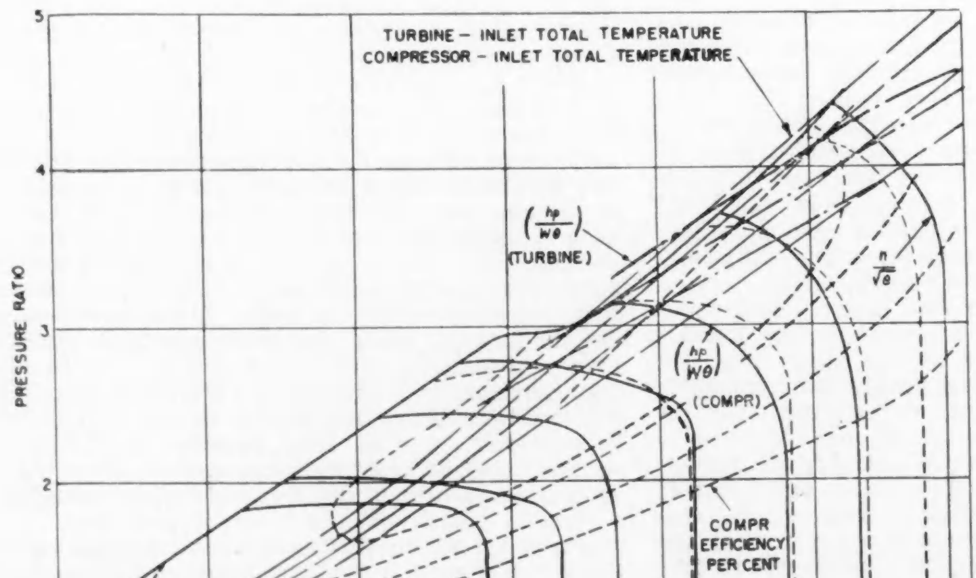


Fig. 2—Relationship of turbine requirements to compressor

Topic at SAE Round Table

REPORTED BY

John R. Foley, Pratt & Whitney Aircraft, Division of United Aircraft Corp.

• Round Table on Compressor Surge was held at SAE Summer Meeting, French Lick, on June 7, 1951, under the auspices of the SAE Aircraft Powerplant Activity. Discussion leader was Walter Doll.

speeds are equated, and the pressure ratio required of the compressor at each flow is determined by the throttling characteristics of the turbine. This sets the equilibrium operating characteristics of the engine; for acceleration, a higher fuel rate is required to provide an excess of turbine torque. The higher temperature gases then require a higher pressure ratio to escape through the turbine, which causes the operating line to move closer to surge.

Thus it can be seen that one of the crucial operating regions occurs where the operating line is swept close to the surge line at low speeds during acceleration of the engine. It was also pointed out that at high altitudes, where the Mach number is increased, the compressor performance tends to be reduced, and the surge line again tends to be in conflict with operating requirements.

Discussion of the effect of compression ratio on the surge characteristics emphasized that the surge line is basically parabolic in shape, which conflicts with the essentially linear demands of the engine operating line. As the design pressure ratio is increased, more and more curvature is found in the surge line, which increases the conflict with the engine requirements. Figs. 3 and 4 show the effect of increasing design pressure ratio.

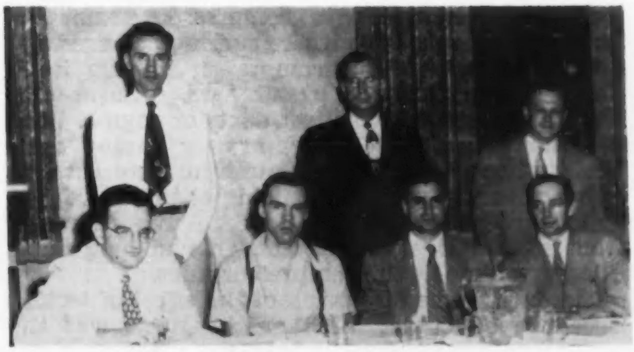
The underlying cause of surge is the stalling of the blades of which the compressor is composed, much as an airplane wing stalls. The problem is more complex, however, in that the stall is sensitive not only to profile shape and angle of attack, but as well to the relationship of one blade to the next—that is, the stagger angle and spacing (solidity) of the cascade of airfoils. Fig. 5 defines these variables, and Figs. 6 and 7 illustrate their effect on compressor performance, as determined from tests of model compressor stages. There was general agreement that increasing the camber, stagger, or solidity tends to increase the pressure rise of a compressor stage, but to make the stall more severe.

The manner in which the stall of the individual stage influences the surge of the compressor as a whole was discussed. Probably the most important effect is the variation in stage matching as the speed of the compressor is varied. Fig. 8 illustrates how the flow area in a compressor is reduced at the discharge to conform to the increased density realized at full speed; during starting this compression is absent, which causes the flow area to be inconsistent with the thermodynamic state of the air. Figs. 9 and 10 show how this results in axial velocities or volume flows too low in the first stage and too high in the last stage. Thus the pressure rise and efficiency are reduced, causing the surge line to dip excessively at low speeds. It is interesting to note that at these speeds a good many of the inlet stages can be stalled before the compressor as a whole surges.

This explains why the surge line becomes worse at higher design pressure ratios, as was shown earlier in the discussion. The higher the design pressure ratio, the greater the disparity in flow area at low speeds. One manufacturer stated that in one compressor this effect had been so drastic that the discharge of the compressor reached sonic velocity and choked before sufficient pressure rise could be built up to force the flow through.

The foregoing reasoning was also used to show that one means of improving the surge line is to improve the range of flow tolerance of the individual stages, in particular the rate at which the pressure rise falls off after the blades stall. The discussion of the more violent stall characteristics of highly loaded blading serves to explain why high performance compressors tend to have worse surge lines.

The internal flow in a stalled stage was shown to



Members of the SAE Summer Meeting panel on compressor surge seated at the "round" table are: J. R. Foley, panel secretary, and Walter Doll, panel leader, both of Pratt & Whitney Aircraft; G. E. Giacchino of Westinghouse Electric; and R. S. Hall of General Electric. Behind them stand panel members R. O. Bullock of NACA; F. R. Short of Allison; and George Sanders of Wright Aeronautical

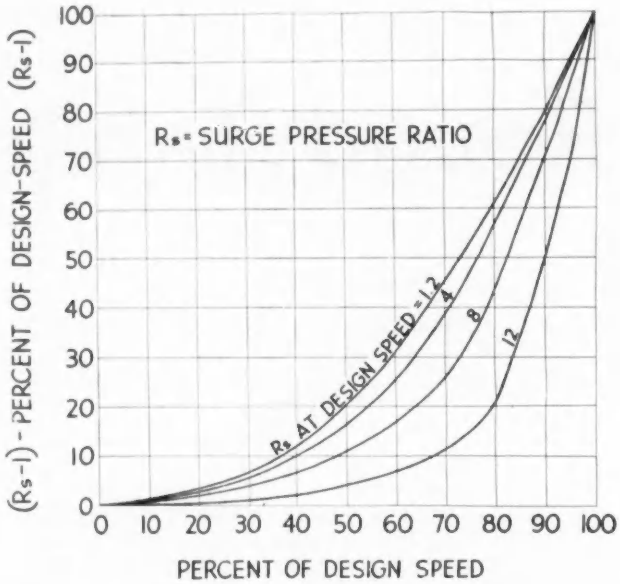


Fig. 3—Effect of increasing design pressure ratio on surge-free pressure ratio

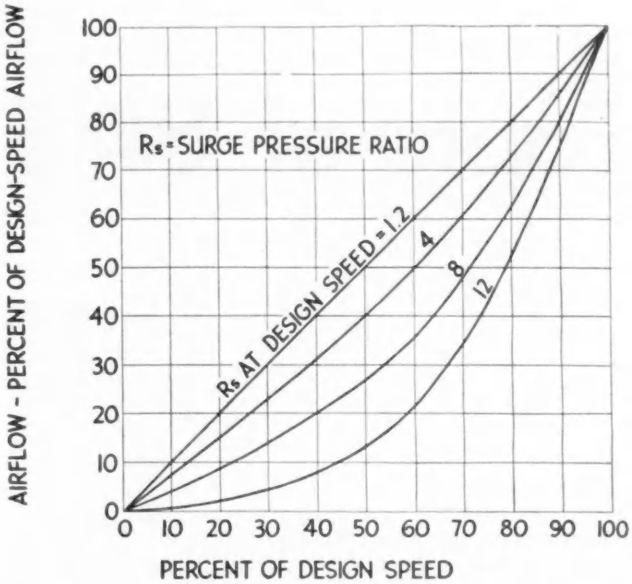


Fig. 4—Effect of increasing design pressure ratio on low-speed airflow

be characterized by a reverse flow region near the rotor tip, as shown in Fig. 11. Several manufacturers confirmed that this phenomenon was observed in multistage compressors. It was pointed out that this recirculation warps the velocity distribution and adversely affects the performance of subsequent stages, reducing the pressure rise as much as 15 or 20%. One engineer stated that the first stage of one compressor performed better in the compressor than when tested alone. It was agreed that this was probably caused by the pumping action of the subsequent stages, which helped to maintain a more uniform flow through the first stage even when stalled.

During discussion of the dynamic or acoustical effects in surge, the equations governing the stability of the airflow were reviewed. From this it was concluded that surge would be encountered at or near the peak pressure rise at each speed. Different mathematical interpretations indicated some variation in what might be expected at low speeds.

Actual experience with compressors seemed to indicate that the point where surging occurred was a function only of the compressor blading itself, whereas the severity of the surge was influenced by the characteristic of the test ducts or engine. One engineer stated that a compressor surged quite gently when the inlet drew air from outdoors, but rather violently when a silencing chamber was installed around the inlet. Concern was expressed about aircraft installations which had long ducts of large volume at the compressor inlet.

There was some discussion of the effect of testing procedure on surge; whether the surge was the same when approached at constant speed as along a constant throttling line similar to engine operation (see Fig. 2), and whether surge could be tolerated if the engine passed through it rapidly enough. No general agreement could be reached on these questions. One engineer pointed out that surge testing was avoided because of bad experiences with blading damage. Another stated that surge could be tolerated if the engine operating line passed out of the surge region at a low enough speed.

The electrical analogy, which is often used to illustrate surge of compressors, was inapplicable in the opinion of one engineer, since the current is analogous to velocity in the continuity equation and to the product of density times velocity in the momentum equation. It was also pointed out that the acoustical problem is not of primary significance, since even if stability could be preserved the reduced pressure ratio and efficiency make operation to the left of the peak pressure ratio undesirable if not impossible.

Measures which the designer may take to alleviate difficulties with surge were discussed. These fall into two categories: those which are inherent in the design of the compressor, and those which involve variation in the engine geometry. The former includes the matching of stages so that they are not operating as far from optimum conditions at low speeds; this usually entails a loss in pressure ratio and efficiency at full speed, and may make surging at high altitude more serious. Another method is to select stages whose flow range is greater; this usually means an increase in the number of stages since these are lightly loaded stages.

Probably the most common method of varying the compressor geometry is the use of interstage bleeds. A certain portion of the compressor airflow is bled off approximately half way through the compressor. This rectifies the discrepancy in volume flow at low speeds mentioned earlier in the discussion, and improves the engine performance in spite of the wasted working fluid. At high speeds, the bleeds may be closed and the stage matching restored to its original state. It was agreed that bleeds constituted an installation and control problem, but might well pay for themselves in improved

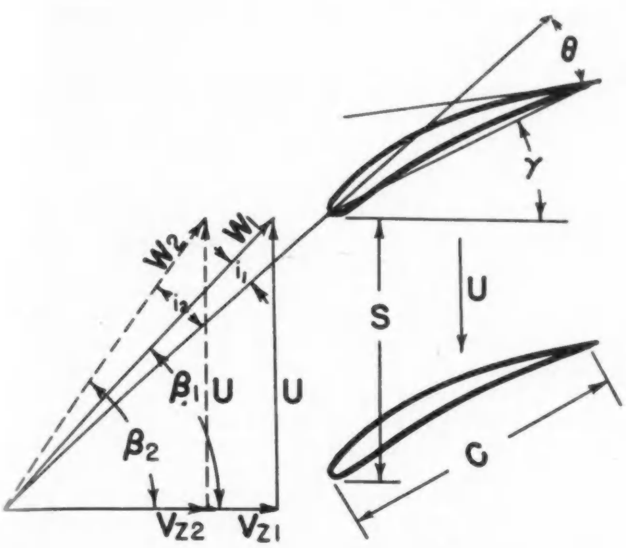


Fig. 5—Explanation of blading symbols

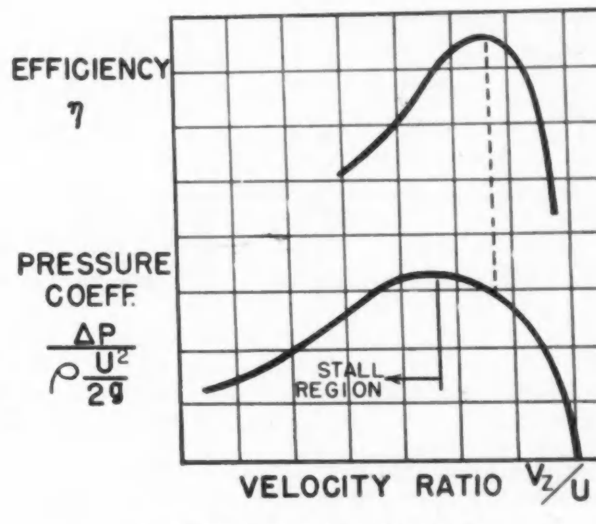


Fig. 6—Single stage characteristic

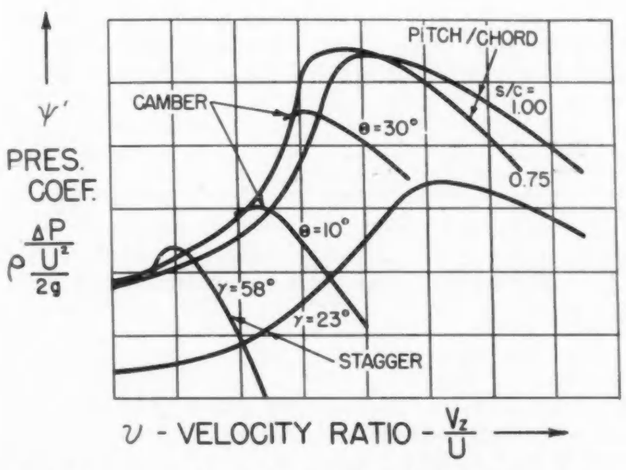


Fig. 7—Pressure coefficient versus velocity ratio for various values of camber, stagger, and pitch-chord ratio

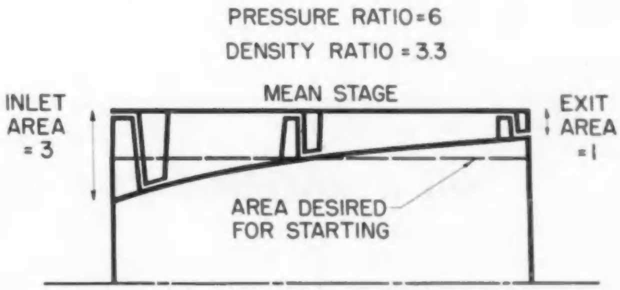


Fig. 8—Typical change in flow area of compressor

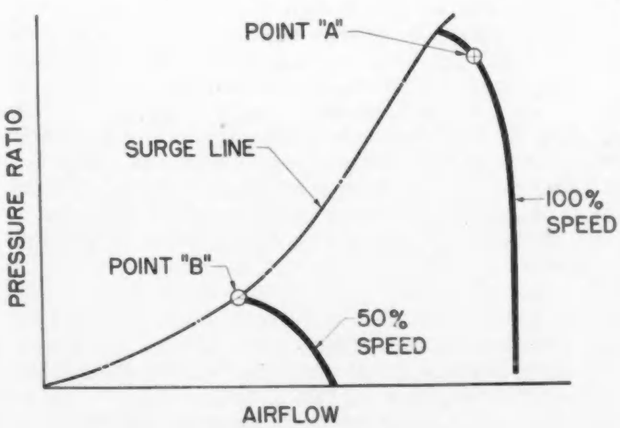


Fig. 9—Operating conditions of compressor

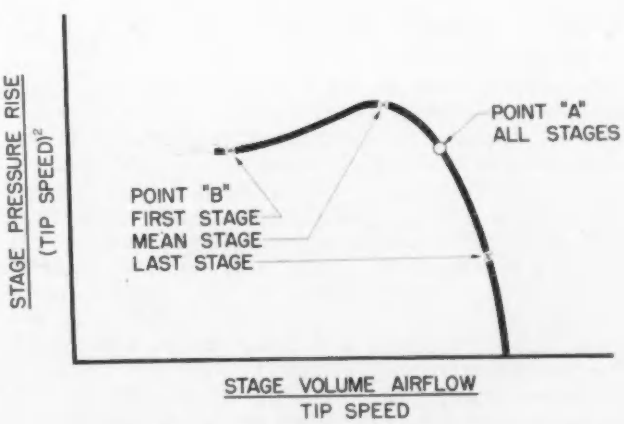


Fig. 10—Operating conditions of individual stages

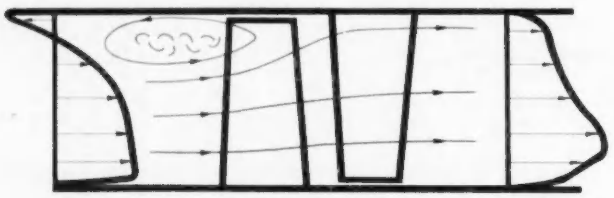


Fig. 11—Typical flow through a stalled stage

high-speed and high-altitude performance, since they reduce the amount of design compromise required for low-speed operation.

Variable inlet guide vanes and variable turbine nozzles were mentioned as being effective means of improving the low-speed performance but rather cumbersome mechanically. It was pointed out that variable turbine nozzles could also be useful for optimum matching of the engine at high powers, but one engineer contended that the turbine efficiency suffered so badly at off-design nozzle angles that the benefits were questionable.

The use of compound compressors was discussed, in which two independent compressors are used in series. It was stated that as the engine operating condition is varied, the two compressors tend to adjust their speeds in such a way as to alleviate the surge characteristics. It was agreed that pressure ratios of 7 to 9 were about the maximum in a single compressor, but that compound compressors might extend this to 12 to 16.

At the request of controls engineers present, the control aspects of surge were discussed. A very useful device, it was suggested would be one which could anticipate the onset of surge and automatically reduce the fuel flow; this would eliminate complex schedules in the control system and compensate for wear and deterioration of the engine. It was agreed that there was no immediate hope for such a device, although one engineer believed some characteristic of the recirculatory flow might be interpreted as an advance sign of surge.

No agreement could be reached on the effect of engine deterioration, dirt accumulation, and production tolerances on the surge problem. Some engineers believed that dirt deposits might cause more loss in performance at low speeds than at high, since the accumulation is probably greater on the inlet stages which are critical at low speeds. It was agreed, however, that there is insufficient experience with any of these effects to allow formulation of any positive conclusions.

SOIL KNOWLEDGE CAN PROVE USEFUL TO DESIGNERS

Continued from Page 41

the angle of travel of the column of soil through the previously loaded soil.

From the preceding discussion these points relative to scraper loading have been established: (1) Cutting resistance is not generally the critical condition, (2) The condition of refusal to load is a function of the resistance of the previously loaded soil, and (3) Power requirements during the loading operation increase markedly as the scraper approaches full load.

A consideration of these three observations suggests as a possible scraper design the one shown in Fig. 8. The apron is located at the rear, and the ejector locks in a forward position during loading, serving as a plane of sliding for the soil entering the scraper. The forward part of the scraper is fixed to the frame and serves a triple purpose. It exerts a confining force on the soil immediately ahead of the cutting edge, serves as a plane of sliding for the soil entering the scraper, and deflects the column of soil into the scraper bowl. The possible advantages are: (1) Reduced frictional resistance against the entering column of soil, (2) Entering soil does not have to "buck" previously loaded material, (3) A relatively uniform power requirement is maintained during the loading operation. The maximum power requirement should be noticeably less than at the point of refusal for a conventional scraper, (4) Complete scraper loading without pusher help.

The most apparent disadvantage in such a design is that boulders above a diameter equal to the clearance between the ejector and the forward plate could not be loaded. Perhaps other benefits outweigh this disadvantage.

Another possible design is shown in Fig. 9. The above items relating to Fig. 8 are also applicable to this scraper. Cradle mounting of this scraper would introduce an advantage over the other scraper in that large boulders could be loaded in the conventional manner from the front. In fact, a forward cutting edge could be attached for the forward loading of rocky soil of a type refusing to load at the rear. Some thought along these lines could lead to a more truly universal scraper.

An analysis of the type applied to scrapers in this paper could be applied to shovels, drag-line buckets, dozer blades, grader blades, compaction equipment —in fact, to most any item of equipment encountering earth resistance.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

ISTC Division VIII Reports on

BORON STEELS

EDITED BY

Harry B. Knowlton, Chairman of ISTC Division VIII—Boron Steels, and Supervisor, Materials Engineering, International Harvester Co.

THE heat-treating grades of automotive alloy steels may be divided into several general classes containing from 0.30-0.65% carbon and varying amounts of alloy. These are used primarily for parts requiring a better degree of strength and toughness than can be readily obtained with commercial processing of carbon steels. In some cases a fair degree of surface hardness may be required for wear resistance, but in many cases hardness specifications are imposed primarily as a guarantee of requisite strength. On this basis the medium-carbon or heat-treating steels may be differentiated from the high-carbon full-hardening steels used for ball and roller bearings, thrust washers, and similar wear resistant parts; and the case-hardening steels initially containing less than 0.30 carbon, but which are carburized, nitrided, or cyanided to produce a high hardness surface layer or "case."

In general, alloys such as nickel, chromium, molybdenum, and vanadium have been added to the medium-carbon steels for the purpose of improving their hardenability so as to produce higher surface hardness on large sections, deeper penetration of hardness, higher strength in critical areas, or to permit the use of less drastic forms of quenching without sacrifice of the required physical properties. The latter is often effective in reducing the dangers of warping, distortion, or the setting up of harmful internal stresses.

The tensile strength at any point on the cross-section is proportional to the hardness at that point. The highest ratio of yield strength to tensile strength, the highest ratio of fatigue endurance limit to tensile strength, and the best combination of toughness and hardness are obtained only when the hardenability is high enough to produce 90% martensite or more, as quenched, before drawing or tempering. In commercial practice, however, such ideal conditions frequently do not prevail at the center of the heat-treated part. Some metallurgists demand a high percentage of martensite only at the critical or most highly stressed location.

There is considerable difference of opinion concerning the required amount of martensite at different points on the cross-section.

In the selection of an alternate steel for any given part, it is usually satisfactory to duplicate the hardenability of the steel currently used for that part. There may, however, be exceptions to this rule where other properties besides hardenability must be considered also.

On this basis the Alloy Bar Division of the American Iron and Steel Institute under the leadership of Porter R. Wray, set up a new series of 80BXX and 81BXX steels which approximately duplicate the hardenability of the 86XX and 41XX types of steels

Second in a Series . . .

SEVERAL families of steel containing boron have been proposed as alternates for conventional alloy steels. The principal requirements are that parts produced with the new steel shall duplicate the strength, toughness, and general serviceability of parts made from the previous standard steels . . . furthermore, that this be accomplished without expensive changes of production processes. Data submitted to Division VIII of the SAE Iron & Steel Technical Committee show that, in many instances, these requirements have been met.

This article—the second of a series—discusses heat-treating grades of boron steels . . . that is, steels between 0.30 and 0.65% carbon. Such steels are used in the automotive industry for axles, shafts, steering knuckles, steering arms, springs, and similar parts.

The first article of this series about boron steel studies being conducted by Division VIII appeared in the August, 1951, SAE Journal. It covered the history and fundamental principles of boron additions and their effects on steel as well as a discussion of the carburizing grades of boron steels and the results obtained with their use for particular applications.

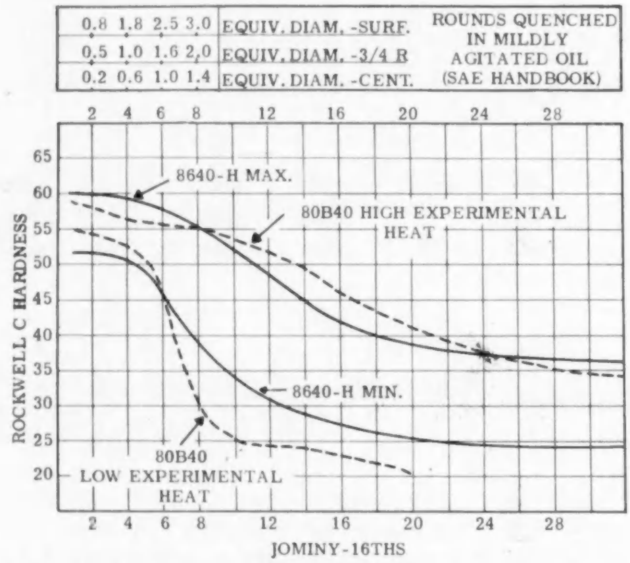


Fig. 1—Hardenability of high and low experimental ingots of 80B40 compared with 8640 H bands

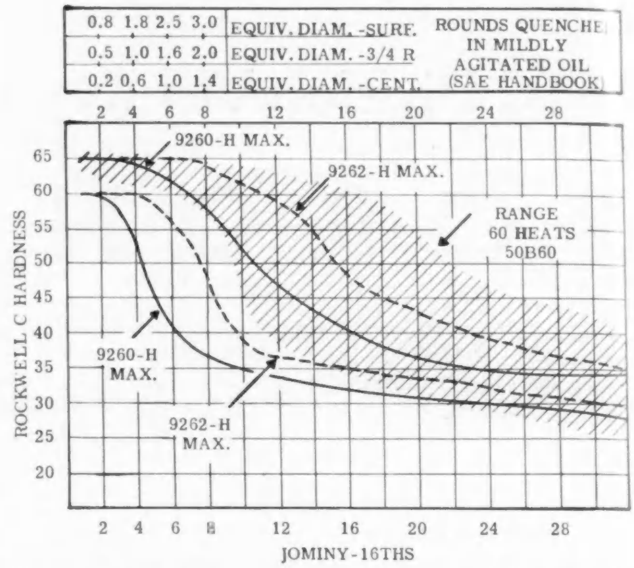


Fig. 2—Hardenability data on 60 heats of 50B60 compared with 9260 H and 9262 H bands

which they are meant to replace. See Table 1. (Compositions for these and other boron steels are given in the AISI pamphlet "Boron Steels 14BXX and 50BXX, July, 1951, Supplementing Alternate Steels, Revised, June 13, 1951." This pamphlet is available from the AISI, 350 Fifth Avenue, New York 1, N. Y.) In setting up the 80BXX and 81BXX steels, Wray and his committee have made a great contribution to the possible conservation of alloying elements.

The boron steel 86B45 has been used by Caterpillar and others as a substitute for 4340. Also, several boron carbon steels have been used satisfactorily; these were originally known as 10TXX steels, but to avoid confusion with plain carbon steels they are now being designated as 14BXX. More recently, Wisconsin Steel in cooperation with engineering and manufacturing departments in divisions of International Harvester has developed a series of 50BXX boron-treated chromium steels, which may be used as alternates for the steels indicated, within proper limitations. (All of the proposed medium carbon boron alloy steels mentioned are shown in the AISI pamphlet.)

Unfortunately it is not possible with a low-alloy boron steel to duplicate the entire hardenability curve of the more conventional types of alloy steel, such as 8640 or 4140. This is because there is a fundamental difference in the shape of the hardenability curves for the low-alloy boron steels and the higher-alloy older-type steels. This is illustrated in Fig. 1, which is redrawn from Wray's article in the July SAE Journal. This illustration shows the Jominy hardenability curves for low- and high-hardenability experimental ingots of 80B40 as compared with the specified range for 8640H. As usual, these curves are plotted in terms of Rockwell hardness at different distances in sixteenths of an inch from the quenched end of the Jominy specimen. The figures for correlating Jominy distance with cross-sectional hardness of different size oil-quenched rounds have been added to the graph. (These correlations were worked out by Boegehold and are taken from the SAE Handbook.)

The specified 8640H band is used as a basis for comparison, rather than the total experience band of 8640 steel because the majority of automotive metallurgists are probably using the H band. It should be remembered, however, that the 80B40 low experimental ingot is very low indeed—probably lower than any which will be received under the 80B40 specification. The steel makers, however, are to be complimented on furnishing such data as a basis for the consideration of the minimum properties which will be obtained with the new steel.

As an example of the use of this graph, it will be noted that 6/16 on the Jominy specimen will correspond in hardness with the surface of a 2.5-in. diameter oil quenched bar, or a point ¾ of the radius from the center of a 1.6-in. round, or the center hardness of a 1.0-in. diameter round.

There is probably no point in automotive metallurgy upon which there are so many differences of opinion, as what constitutes the most desirable penetration of hardness over the cross-section of similar parts. There may be no doubt that bolts, studs, and other parts subjected to uniform tension, are benefited by a uniform hardness over the entire cross-section. For parts such as steering knuckles, axles, and shafts, which are subjected to bending or torsion, the maximum stress appears at the surface, while there is little or no stress at the center or neutral axis. However, the successful performance of such parts depends not only upon the hardness and strength at different points on the cross-section, but is also affected by the residual stresses which are set up by heat-treatment. This varies with the hardenability of the steel, the size and shape of the piece heat-treated, and the details of the quenching and tempering processes. The whole problem is too complicated for discussion during the meetings of Division VIII. Suffice it to say that some metallurgists prefer 90% martensite at the center, while others are content with a similar, or

sometimes even smaller percentage of martensite, at ½-radius or ¾-radius points. One group favors determining hardness and strength at the most highly stressed point on the cross-section, which is usually between the ¾-radius point and the surface.

It was attempted only to point out that there is a difference between the hardenability curves of the boron and the other alloy steels, and to show how the curves may be used in selecting steel for any given application. For example, up to 6/16 on the Jominy bar, the minimum heat of 80B40 steel shows as good or better hardenability than 8640H. This means that in terms of hardness of oil-quenched rounds, it will develop as high surface hardness up to diameters of 2.50 in. Similarly, it will develop hardness at ¾ radius up to 1.6-in. diameter, and center hardness up to 1.0-in. diameters. For larger sections, the 80B40 might not develop quite as good hardness at the points indicated, as obtained with the minimum of the 8640H range.

On the other hand, the lower hardenability of the boron steels toward the right side, or slowly cooled portion of the Jominy diagram, may have some merits, as it indicates slightly better cold-forming properties.

While selection of alternate steels on the basis of hardenability works satisfactorily in the great majority of cases, there may be exceptions to the rule. Warnings have been given in Division VIII meetings that with excessively high tempering temperatures it was sometimes possible to produce temper brittleness with the boron steels. Warnings have been given also that there might be a loss in toughness in terms of cold impact strength in any section where the structure was not completely hardened before tempering. Some metallurgists are very concerned about notch-bar toughness (so called impact strength) of heat-treated steels, while other automotive metallurgists seem to feel that the toughness obtained with present steels and heat-treating practices is adequate without requiring notch-bar impact tests at ordinary or depressed temperatures.

Some of the automotive metallurgists consider that the best tests of new steels are simulated service tests of actual production parts made from these steels and heat-treated in a commercial manner. Actual field performance of finished parts is of course the ultimate goal. A large number of tests involving the complete allowable range of composition and hardenability of steel and the entire gamut of service conditions is necessary to determine the relative merits of different materials on a service basis. This requires much time and many heats of steel. Only a few items have reached this stage of development and testing.

A considerable portion of the meetings of Division VIII has been devoted to discussing the results obtained on finished parts made of the various types of boron steels, as compared with results obtained with the more conventional steels.

Bolt Steels

Discussion has indicated that the boron treated steels can probably be used to replace other alloys for many heat-treated bolts. Caterpillar has been using 14B35 for oil-quenched bolts up to and includ-

Table 1—Chemical Compositions of Certain Boron Steels in the Medium-Carbon Range

Grade	Chemical Composition Limits, %					
	C	Mn	Si	Ni	Cr	Mo
50B30	0.27/0.34	0.70/1.00	0.20/0.35	—	0.35/0.60	—
50B35	0.32/0.39	"	"	—	"	—
50B40	0.37/0.45	"	"	—	0.35/0.60	—
50B44	0.42/0.50	"	"	—	"	—
50B49	0.47/0.55	"	"	—	0.20/0.40	—
50B50	"	"	"	—	0.35/0.60	—
50B60	0.55/0.65	"	"	—	0.35/0.60	—
80B30	0.27/0.34	0.55/0.80	0.20/0.35	0.20/0.45	0.15/0.35	0.08/0.15
80B35	0.32/0.39	0.65/0.95	"	"	"	"
80B40	0.37/0.45	0.70/1.00	"	"	"	"
80B45	0.42/0.50	"	"	"	"	"
80B50	0.47/0.55	"	"	"	0.25/0.50	"
80B55	0.50/0.60	"	"	"	0.30/0.55	"
80B60	0.55/0.65	"	"	"	"	"
81B35	0.32/0.39	0.70/1.00	0.20/0.35	0.20/0.40	0.30/0.55	0.08/0.15
81B40	0.37/0.45	"	"	"	"	"
81B45	0.42/0.50	"	"	"	"	"
81B50	0.47/0.55	0.75/1.05	"	"	0.35/0.60	"
TS 86B45	0.43/0.48	0.75/1.00	0.20/0.35	0.40/0.70	0.55/0.75	0.08/0.15
[a] 40B37 Modified	0.34/0.42	0.70/1.00	—	—	—	0.08/0.15
[a] 14B35	0.33/0.40	0.70/1.00	—	—	—	—
[b, c] 40B37	0.34/0.42	0.70/1.00	—	—	—	0.20/0.30
[b] 80B37	0.34/0.42	0.70/1.00	—	0.20/0.40	0.15/0.35	0.08/0.15
[b] 50B37	0.34/0.42	0.70/1.00	—	—	0.20/0.40	—

[a] For cold heading and cold forging wires for component sizes to ½ in. diameter, inclusive.
[b] For cold heading and cold forging wires for component sizes over ½ to ¾ in. diameter, inclusive.
[c] For aircraft applications.

ing 7/16 in. in diameter, and water-quenched bolts from 7/8 to 1 1/4 in. in diameter, for a number of years with entirely satisfactory results. It was reported at one meeting that the most difficult bolt to make is the Place head bolt. So far, 4035 or 4037 molybdenum steels have proved the best for manufacture of this type of bolt. The forming of the Place type head has not been satisfactory with plain carbon steel material. Thompson of American Steel and Wire has reported encouraging results, however, with a steel containing 0.08-0.15% molybdenum boron-treated for bolts under 1/2 in., and 14B37 and 50B37 for bolts over 1/2 in. Proposed analyses are shown in Table 1.

Spring Steels

In the past, both flat and coil springs for automotive uses other than valve springs have been made from 9260, 9261, 9262 silico-manganese steels; 5150-5160 chromium steels; 8650-8660 chromium-nickel-molybdenum steels; and 6150-6160 chromium-vanadium steels. Probably the most important requirement for alternate steels is that they duplicate the hardenability of the steels used, at least far enough out on the Jominy specimen to guarantee the same cross-sectional hardness of the final part when given the usual quench. Steels 80B50, 80B60, and 50B60 have all met these requirements for certain classes of springs. So far, mechanical performance tests have also indicated that springs made of these materials will give satisfactory performance.

Wisconsin Steel in conjunction with Standard Steel Spring Co. has developed the 50B60 steel containing 0.70-1.00% Mn, 0.20-0.35% Si, and 0.35-0.60% Cr. Fig. 2 shows the results of Jominy hardenability tests of 60 heats of this type of steel in comparison with the specified hardness ranges for 9260 H and 9262 H. No difficulties have been experienced with the fabrication of springs up to 1-in. thickness from this type of steel.

Abridgments of reports on heat-treating grades of boron steels contributed to Division VIII follow.

Data on 14B45, 80B50, and 80B60 from E. T. Bittner of American Steel Foundries

Summarizing our experience with boron-treated steels to date, results have been very favorable for applications involving hot-formed, helical compression springs. Considering basic factors of surface conditions, and adequate hardenability to yield approximately 50% martensite at the center of any given as-quenched section, we have found (from other work also) that carbon content and alloying elements can be varied within wide limits without affecting quality of product. Heat-treatment is modified to obtain desired hardness and microstructure, and it has not been found necessary to impose limitations such as minimum tempering temperatures.

The following information on 14B45 grade may be of general interest in evaluating the response of 0.40 to 0.50% carbon steels, although it is of no immediate practical value for springs of heavier bar sections.

For the five heats of 14B45 steel, the range of base analysis was 0.45-0.49% carbon, 0.68-1.15% manganese, 0.22-0.28% silicon, and 0.03-0.13% chromium plus nickel plus molybdenum. Grainal 79 was added. Table 2 shows the hardenability. The J-50 distance extended to 3 1/2-6 1/2 sixteenths.

Sections up to 19/32 in. in diameter were oil quenched and tempered; larger sections up to 1 1/8 in. in diameter were water quenched and tempered. Their as-rolled hardness measured 183-248 Bhn; their as-quenched hardness (from 1550 F) measured 57-60 Rc. Microstructure was all martensite at the surface and at least 90% martensite at the center. Decarburization extended from 0.003 to 0.020 in. Table 3 compares some of the physical properties of 14B45 with SAE 8650 H and SAE 8660 H.

A limited number of fatigue tests has been made on the 14B45 steels. They have consisted of Rayflex-type reversed bending tests on heat-treated

Table 2—Hardenability Range of Five Heats of 14B45

Distance in Sixteenths	1	2	3	4	5	6	7	8	16	24
Rc maximum	57	57	55	41	30	29	28	27	23	16
Rc minimum	59	58	57	56	56	53	45	33	26	21

Table 3—Comparison of 14B45 with SAE 8650 H and SAE 8660 H

	14B45	8650 H 8660 H	14B45	8650 H 8660 H
Tempering Temperature, F	550	600	750	850
Tensile Strength, 1000 psi	241/265	251	200/202	211
Yield Strength, 1000 psi (0.2% offset)	213/233	217	186/187	190
Elongation, %	11/13.5	9.5	14.5/16	13
Reduction in Area, %	41/53	28	53/58	42.5
Single Width V-Notch Charpy, ft-lb	16/26	12	25/32	19
Room temperature, −40 F	15/26	9.5	18/23	16.5

Table 4—Analysis of Heat No. 47310 of 81B45

	C, %	Mn, %	Ni, %	Cr, %	Mo, %	B, %
Vendor	0.43	1.06	0.28	0.32	0.11	0.0012
Eaton	0.47	1.06	0.24	0.34	...	0.0015

Table 5—Hardenability of Heat No. 47310 of 81B45

Distance in Sixteenths	1	2	3	4	5	6	7	8	10	12	14	16	20	24	28	32
Rc	58.5	58	57.5	57	57	56.5	56.5	56	55	54.5	53	50.5	45	40.5	36.5	34.5

bars with hot-rolled surface, and also tests on hot-wound springs. Average results on reversed bending tests show thus far that the 14B45 has a life of approximately 200,000 cycles compared to 125,000 cycles for 8600 H steels at a stress level of 60,000 psi maximum surface stress (or range of 120,000 psi).

Limited fatigue tests on flat bars of the 14B45 steel gave poor results compared to the 8600 H steels. No further work has been done on these sections.

Sufficient material is on hand for production runs of 80B50 and 80B60 steels.

Analysis of the 80B50 grade showed 0.52% carbon, 0.98% manganese, 0.27% silicon, 0.34% nickel, 0.44% chromium, and 0.13% molybdenum. Grainal 79 was the boron addition. Hardenability was J-58 at 16 sixteenths and J-49 at 28 sixteenths.

Approximately 3000 coils of 15/32 in. bar diameter have been processed as follows: coiled at 1500 F and air cooled, oil quenched from 1550 F, tempered at 800 F and water quenched. Initial hardness was 60-62 Rc; final hardness was 429-461 Bhn.

No difference in any part of the processing was observed from the 8650 H usually used for this spring.

Analysis of the 80B60 grade showed 0.62% carbon, 0.93% manganese, 0.30% silicon, 0.42% nickel, 0.53% chromium, and 0.15% molybdenum. Hardenability was J-60 at 20 sixteenths and J-48 at 32 sixteenths. No springs have been manufactured in the shop from this grade as yet. However, all preliminary tests indicate favorable results comparable to the usual 8660 H steel.

—June 14, 1951

Data on 86B45 From G. D. Riegel of Caterpillar

In our judgment, little difficulty need be expected in replacing the through-hardening or deep-hardening types with the boron-treated alloy steels. Perhaps the danger of too intense hardenability, resulting in excessive distortion or cracking, would be the principal hazard. Some months ago, we obtained a heat of boron-treated 86B45 steel which hardened to Rockwell C 55 at the center of a 3½ in. diameter shaft quenched in still oil. Since this was a shaft with splines, we finally had to resort to martempering in order to avoid the complete loss of the parts by cracking to the center. They cracked in ordinary oil quenching even though the oil had been heated to almost 300 F. In these deep-hardening or through-hardening types, one should guard against too high tempering temperatures and loss of notch toughness. When the red-heat range of the tempering temperature is approached or exceeded, we have found that a very abrupt drop in the foot-pound values on the Charpy impact test results, especially at reduced temperatures.

Since 1939, our firm has used more than 50,000 tons of boron-treated steels. Of those purchased by mill heat lots, about 30,000 tons have been of the old 10T35 type and about 20,000 tons of the old 86T45 types. There are distinct processing advantages in the use of these steels from the standpoint of cold and hot working, annealing, and machining. In cold heading, shearing, and threading, there may be as much as 35 to 100% increase in die life.

For the same sectional hardenability, the boron-treated steels add no mineralogical hardness for the corresponding hardening intensity imparted by the boron. In other words, an 86B45 composition anneals just as readily as does 8645 without the boron but hardens on liquid quenching much the same as high-side 4340. This is quite advantageous in shortening annealing time and for reducing the cost of metal removal in machining prior to hardening.

Generally speaking, our experience has shown that in using boron-treated steels, we have had to reduce the carbon content of the steel it replaced by as much as three to five points. This should be helpful for components which are welded in field operations. Carbon is the most embrittling element in weld bead cracking.

There is one prime factor of disadvantage in using the lean-alloy boron-treated steels to replace the common constructional grades of alloy steel—namely, the higher temperatures necessary for retaining ferrite in solution during quenching. This produces more distortion and unless more energetic means are used for abstracting the heat properly, there may result a poor product and high scrap loss. Once the techniques have been mastered however, no particular difficulty need be encountered unless one runs into excessive hardenability.

Pilot lots of any part made from the lean-alloy steels should be run to gage these problems before any large quantities of parts have been machined ready for heat-treatment. This is particularly true for gears, spline shafts, key-seated parts, and other items subject to damage by distortion in heat-treatment.

There is no need to be concerned about notch toughness or notch sensitivity in the boron-treated steels if the tempering temperatures are under 800 F. If the hardening has been properly performed, they are usually superior to the types they displace.

The alloy steel mills have generally been as successful in providing suitable boron-treated steels of uniform quality throughout the delivered lot as with any other alloy steels. The hardenability tests taken at the extremes of the mill heat prove or disprove this fact. Actually, we have had fewer rejections of mill heats of boron-treated steels from our several sources of supply than we have had from the comparable grades which they replaced.

—April 12, 1951

Data on 81B45 and 94B30 from T. A. Frischman of Eaton Manufacturing

Grade 81B45 steel was investigated for axle shafts and high-speed clutch plates and grade 94B30 for a truck axle steering knuckle.

81B45 Steel—Torsional properties and metallurgical characteristics of axle shafts made from 81B45 steel were compared with those of shafts made from our regular steels of the 41XX H and 43XX H series. All three steels were tested in the same part number to make the comparison. Shaft diameter is 1 9/16 in. Weight is 26½ lb.

Surface, half radius, and center all measured 388

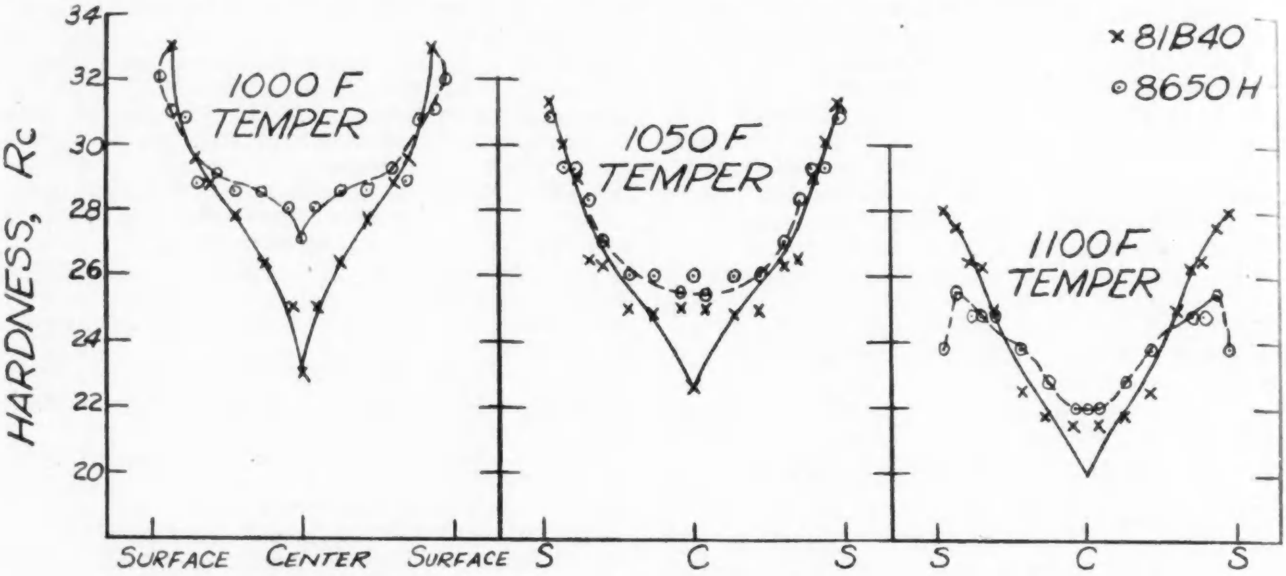


Fig. 3—Plots of cross-sectional hardness surveys on discs of 81B40 and 8650 H steels tempered at 1000, 1050, and 1100 F

Table 6—Torsion Test Results on 81B45 Test Axle Shaft

Type Steel	Yield Strength (psi)	Ultimate Strength (psi)	Twist (deg)	Brinell Hardness		
				Surface	½ Radius	Center
81B45	106,000	141,600	513	388	388	388
81B45	109,000	144,000	477	375	388	388
4340 H	118,500	153,000	1050	415	401	388
4147 H	108,400	160,400	557	415	...	...

Table 7—Hardenabiilty of Heat No. 3L074 of 81B45

Distance in Sixteenths	1	2	3	4	8	12	16	20	24	32
Rc	60	59	58	58	57	51	40	37	34	32

Table 8—Bend Test Results on 81B45 Test Clutch Plate

Sample No.	Steel	Initial Crack, lb	Hardness, Rc	
			Surface	Internal
1	81B45	30,850	52	49.5
2	81B45	31,250	53	49.5
3	8645	18,700	52	49.5
4	8645	20,650	53	49.5

Table 9—Analysis of Heat No. 14L216 of 94B30

	C, %	Mn, %	Ni, %	Cr, %	Mo, %	B, %
Vendor	0.32	0.91	0.46	0.50	0.11	.....
Eaton	0.317	0.90	0.43	0.48	0.12	0.001

Bhn. Specification for the part made from 4340 H steel calls for 388-444 Bhn. Table 4 shows the chemical analysis and Table 5 the hardenability data for the 81B45.

The test axle shaft was heated to 1550 F, oil quenched, and tempered at 875 F. Table 6 shows the results of torsion tests.

Up to 20/16 on the hardenability curve, this heat of 81B45 was within the standard band for 4340 H steel. The good hardenability of the heat is reflected in the surface and internal hardness of the test axle shafts made from it. Also, the torsional yield strength and ultimate strength are close enough to those of the regular materials so that the 81B45 steel may be considered as a possible substitute material.

Grade 81B45 steel from Heat No. 3L074 was studied as a substitute for SAE 8645 steel for high-speed clutch plates. Specification for this part calls for a hardness of Rc 50-56.

Analysis of this heat showed 0.43% carbon, 0.80% manganese, 0.36% nickel, 0.45% chromium, 0.13% molybdenum, and 0.00074% boron. Table 7 shows the hardenability.

The 81B45 test high-speed clutch plates were oil quenched from 1560 F and tempered at 425 F. Response to annealing treatment and machining characteristics were the same as SAE 8645 parts. Table 8 shows bend test data.

The microstructure of the 81B45 steel was completely martensitic. The bend test indicated good

Table 10—Hardenability of Heat No. 14L216 of 94B30

Distance in Sixteenths	1	2	4	6	8	10	12	14	16	20	24	28	32
Rc	53	53	53	52	52	52	51	49	47	43	39	36	34

oughness for the 81B45 steel in comparison with the regular SAE 8645 steel; in fact, the initial crack occurred at a load approximately 50% higher. Surface and internal hardness were equivalent.

The hardenability curve for this experimental heat lies within the standard band for 86B45 H steel.

94B30 Steel—Mechanical properties and hardness of a truck axle steering knuckle made from 94B30 were investigated. (The part is ordinarily made from SAE 8640 steel.) Table 9 gives the chemical analysis and Table 10 the hardenability data for the 94B30 steel.

The test spindle was heated to 1550 F, quenched in oil, and tempered at 950 F. Hardness on the spindle as quenched was 415 Bhn. After tempering, it was 321-285 Bhn on the spindle. (The specification calls for 341-285 Bhn on spindle bearing.) Quarter section and center both measured 255 Bhn.

Table 11 shows the results of tension tests. The tensile test specimen was taken from the half-radius position of the spindle bearing diameter. Hardness of the specimen was 255 Bhn.

The mechanical properties and hardness are in conformity with the specifications for the part. The data show that Heat No. 14L216 of 94B30 steel is an adequate substitute for 8640 steel in this part.

—June 6, 1951

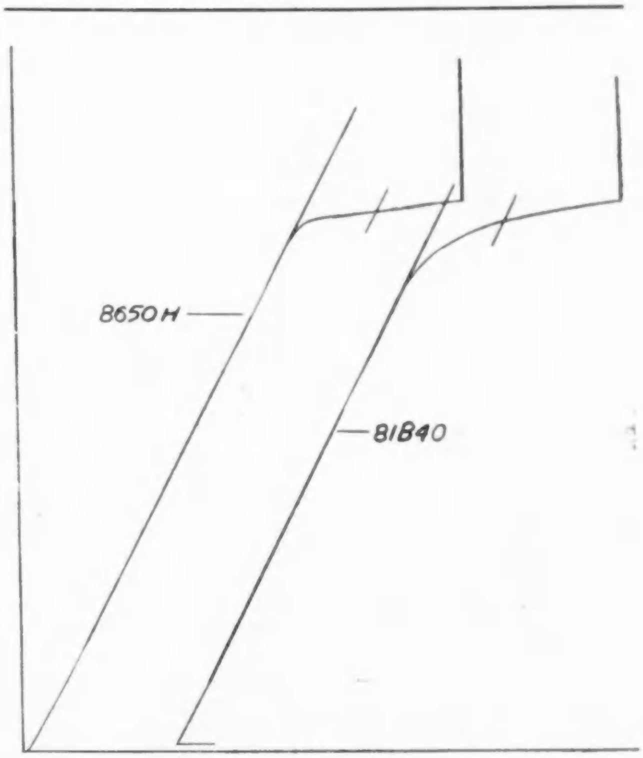


Fig. 4—Stress-strain characteristics of 81B40 and 8650 H steels tempered at 1000 F

Data on 81B40 from R. H. Lundquist of Minneapolis-Moline

Comparative tests were made on samples taken from Heat No. 104794 of 81B40 and Heat No. 114347 of 8650 H. ASTM Grain Size was 7 for both steels. Table 12 give the analyses and Table 13 the hardenability data.

Three sample bars of hot-rolled 2⅞ in. rounds from each heat were furnace heated side by side to 1550 F and oil quenched after 4 hr. One bar from each heat was tempered for 4½ hr at 1000 F, at 1050 F, and at 1100 F. Condition prior to heating and quenching was the as-received hot-rolled structure.

Fig. 3 shows the result of cross-sectional hardness surveys on discs cut from the 2⅞ in. rounds.

Standard 0.505 in. tensile test bars were turned from the bars with the neutral axis of the test bars at a distance of ⅜ in. from the original hot-rolled bar surface. Table 14 shows the physical properties.

It can be seen that physical properties were found to be reasonably comparable except for proportional limit. Fig. 4 illustrates the difference in stress-strain characteristics between the two steels heat treated in an identical manner. Note the more rounded curve for 81B40. This characteristic also held true for the samples tempered at 1050 F and 1100 F.

No definite conclusions can be reached on the basis of these limited tests on single heats. However, we are of the opinion that:

1. Grades 81B40, 81B45, or 81B50 held considerable promise as being acceptable substitutes for 8650 H.
2. More work should be done to determine why

Table 11—Tension Test Results on 94B30 Steering Knuckle

	Specification	Found
Minimum Yield Point, psi	105,000	118,000
Minimum Yield Strength (0.2% offset), psi		105,000
Minimum Tensile Strength, psi	120,000	130,375
Minimum red. of area, %	50	52.5
Minimum elongation, %	13	20

Table 12—Analysis of Heat No. 104794 of 81B40 and Heat No. 114347 of 8650 H

Steel	C, %	Mn, %	P, %	S, %	Si, %	Ni, %	Cr, %	Mo, %	B, %
81B40	0.40	0.85	0.020	0.023	0.27	0.33	0.48	0.13	0.0011
8650 H	0.48	0.82	0.016	0.023	0.26	0.58	0.49	0.22	.....

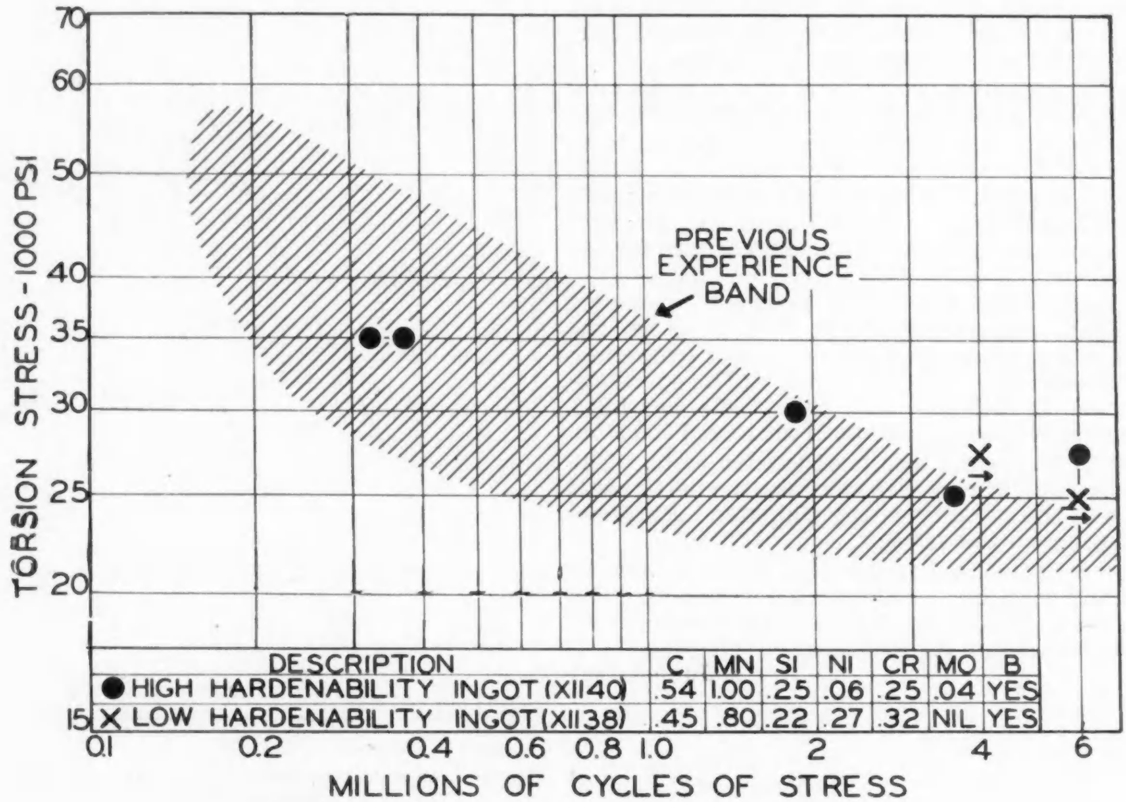


Fig. 5—Torsion fatigue tests on Farmall M rear axle 50B47 steel

there is such a discrepancy between calculated hardness in large rounds using end-quench data and the actual hardness obtained through regular heat-treatment of the large rounds.

It can be seen that the 81B40 tested shows a considerably higher curve at the points significant for a 2⅞ in. round, but the actual results shown by cross-sectional surveys in Fig. 3 go contrary to what should be expected.

3. The considerably lower proportional limits experienced with the 81B40 at substantially the same hardnesses as the 8650 H also require clarification.

Table 13—Hardenability of Heat No. 104794 of 81B40 and Heat No. 114347 of 8650 H

Distance in Sixteenths	1	2	4	8	10	12	16	20	24	28
81B40, Rc	56	56	55	55	55	54	50	44	38	34
8650 H, Rc	61	61	60	55	50	43	37	35	33	32

The "roundhouse" curve shown in Fig. 4 for 81B40 is rather disturbing.

—June 7, 1951

Data on 50B47 from Frank Sailer and C. O. Parish, International Harvester

Two lots of 50B47 steel representing relatively low and high hardenability were fabricated into tractor axles, which were heat-treated for a surface hardness of 321-388 Bhn. The results of torsion fatigue tests are shown in Fig. 5. The shaded area represents previous experience with several types of steel and a large number of axles. It will be noted that the experimental data for the new axle shafts fall in, or above, the previous experience band. The critical section of this type of axle is a spline section of 2.75 in. diameter. Failures usually occur in the spline section.

Table 14—Physical Properties of 81B40 and 8650 H Tempered at 1000, 1050, and 1100 F

Designation	81B40	8650 H	81B40	8650 H	81B40	8650 H
Temper, F	1000	1000	1050	1050	1100	1100
Tensile Strength, psi	136,500	141,000	133,000	140,000	126,500	129,500
Proportional Limit, psi	91,500	102,000	90,000	101,000	91,500	94.500
Yield Strength (0.2% offset), psi	107,000	109,000	104,500	106,500	99,000	97,000
Reduction in Area, %	59.3	58.9	59.8	58.4	61.0	61.0
Elongation, %	19.0	19.0	18.0	21.0	21.0	22.0

Appearance Maintenance

REPORTED BY

Henry Jennings of "Fleet Owner"

• Round Table on Polishing the Paint was held at SAE Summer Meeting, French Lick, June 4, 1951, under the auspices of the SAE Transportation and Maintenance Activity. Discussion leader was G. W. Johnson.

FLEET operators at French Lick agreed that vehicle appearance maintenance does not lend itself to standardized procedures. It is the same old story that applies to almost all maintenance. Much depends upon how good the result has to be, what conditions the vehicles operate under, and how much money the operator has to spend.

Food and beverage distributors who attempt to whet appetites by advertising are justified in spending more money than the operators of service vehicles. Other highly competitive businesses find it desirable to spend larger amounts of money on appearance, especially where delicate colors are used.

One big surprise of the round table session was the report that some operators of dump trucks and cement mixers are spray waxing once a month. Thus a relatively simple washing operation will remove unsightly, tightly-adhering gook that accumulates later on. And what's more, since these trucks get coated so thickly, this system makes for less interference with maintenance and operation.

Equally surprising were the differences in procedures and results of appearance maintenance in one public utility fleet. The trucks of this fleet operate from the Gold Coast of Chicago to the muddy hamlets of southern Illinois. And the operator has been instructed to maintain a good average for the location in which the trucks work. This means spic and span vehicles in the snootier sections and some fairly shabby looking one among the hardy folk who don't care much about looks.

Listening to a speaker from the floor at the Polishing the Paint Round Table are E. F. Donham, Illinois Bell Telephone Co.; Moderator G. W. Johnson, Bowman Dairy Co.; and Henry Jennings of "Fleet Owner," secretary for the session

This is an administration policy and has nothing to do with fleet operation decisions. Some district superintendents like to polish—others prefer to wash and paint. But in either case where requirements are similar, costs come out about the same. The polish boys get a little longer paint life but the wash and paint boys spend less time on labor. So long as appearance and cost stay in line, top management does not interfere.

Results of one survey indicated that more fleet operators apply wax or polish than do not. (The figures were 280 pro and 259 con.) However, a scattering of letters from large fleet operators collected by Chairman Glenn Johnson gave the opposite result.

A novel method of testing the porosity of finish coating was described by one operator. A blotter is sandwiched between a sample of the coated stock and a copper plate, which are connected to a battery with suitable switches. Current causes a leaking of the coating onto the blotter. Initially, a waxed paint seemed to be less porous than an unwaxed one but after some service it appeared to be more porous. This test would have been more indicative of a general result if it had been made with aluminum paint which has certain peculiar characteristics of its own.

There was general agreement that three hand-rubbed wax jobs about equaled the "overnight" paint job in cost. However, it was pointed out that a great deal of difference exists in the amount of rubbing required with different cleaner-polishes. Another operator said that power brush-operated washers scrubbed all the wax off the surface but that he was able to repaint twice as often because of reduced washing costs.

Sealing the interior wood of a body with aluminum paint was recommended as a cure for rust color spots on light exterior paint. This is based on the premise that moisture is coming from the inside out. One operator cured corrosion from milk products by placing galvanized pans with drip holes in strategic places to route the fluid away from critical spots.

Pressurized paint cans came in for praise as a medium of touching up scratches and abrasions. While paint is expensive in small quantities when packed in pressurized cans, it eliminates the loss of a quart of paint and either the time required to clean a brush or loss of a brush from neglect.

CRC Projects, 1951

AT the present time approximately 65% of Coordinating Research Council projects are either being carried out at the express request of the military services, or are projects in which the military is vitally interested—and to which it is contributing support.

Altogether, CRC is currently working on 50 projects, 21 of which were initiated during the past year.

Fuels and Equipment Research

The increased activity in military matters, which was just starting last year, is continuing at an accelerated pace. At present, the Coordinating Fuel and Equipment Research Committee has about 14 major projects under active investigation, with some 8 additional in the preliminary study stage.

The project covering research on the fundamentals of detonation of liquid hydrocarbons in spark-ignited piston engines by means of high-speed photography, supported by the U. S. Navy Bureau of Aeronautics, is progressing satisfactorily. Equipment has been obtained and will be set up shortly at the Battelle Memorial Institute, and the preliminary runs will be started in the near future. The CFR has also authorized a preliminary evaluation of possible methods of measuring instantaneous combustion temperatures. This evaluation, costing $5,000, has been assigned to four universities. The University of Michigan is studying radiation techniques, the University of Wisconsin absorption techniques, the Massachusetts Institute of Technology sound-velocity techniques, and Columbia University thermocouple techniques.

At the request of the military services, a project has been set up to investigate the storage stability of diesel fuels, turbine fuels, aviation gasoline, and motor gasoline. The Group will report directly to the CFR and will study questions of storage stability, methods of handling, and the deposits in induction manifolds, carburetors, and so on. This project has been given a high priority.

During 1950, the combined efforts of the Standard Equipment and Field Survey Panels of the Equipment Survey Group of the Motor Fuels Division were concentrated on a field equipment survey of commercial vehicles in heavy-duty service. The data from this survey are being organized into a report which will be released early this fall. Thirty organizations participated in work on 192 vehicles, using 14 makes of engines, covering a range of displacement from 216 to 855 cu in. The data secured show that the curve of maximum octane number requirements versus the percent of vehicles satisfied for commercial-type gasolines parallels similar curves for passenger cars, except that it is approximately one octane number lower. The program for 1951 includes three separate but closely interrelated octane number requirement projects, as follows:

1. A statistical survey of postwar cars according to the national registration figures.
2. A study of new engine and transmission designs, and of high-requirement cars.
3. An investigation of the change in octane number requirement in cars of a given make and model with accumulated mileage.

A very comprehensive and detailed program has been laid out on 419 cars which have been selected in a manner such that all three of the octane number requirement projects can be carried out concurrently. The Division believes that it must be completed essentially as outlined if the three objectives are to be attained.

The 1950 program of the MFD Road Test Group has been completed, and the data are now being analyzed. Preliminary examinations indicate that the Standard Borderline and Modified Borderline techniques give similar results.

A report entitled "Road Rating Techniques," describing the current road testing techniques, has been circulated to the members of the Motor Fuels Division with the recommendation that it be released to the CFR, and, after approval by that Committee, to the Sustaining Members for publication or general distribution. The 1951 exchange test program has been set up to establish the reproducibility of the test techniques. Two of the commercial-type fuels which will be run in the field equipment survey program will be used.

The single-cylinder laboratory engine program is continuing its study of techniques to permit the investigation of variables of cylinder design and fuel characteristics which influence antiknock quality without the added variables existing in multicylinder engines and highway operation.

The Petroleum Administration for Defense, in response to the CRC offer of its services, has indicated

hat a tentative program which was approved in principle by the CRC Assignment Committee is constructive, and has furnished estimates of fuel antiknock quality which might be available during the emergency so that the program might be carried out.

This program calls for making available to the automotive industry a series of fuels which would bracket the quality levels that might be encountered. These fuels would be used by the equipment manufacturers in a continuous study of the various adjustments which could be made to permit their use by the motoring public, so that fixes would be ready when and if lower quality fuels were distributed.

The Gasoline Engine Equipped Vehicles Advisory Committee has considered this proposed project and recommended that the CFR designate a study group to consider the problem of adjustment of automotive equipment, both passenger and commercial vehicles, to the changing fuel situation and make recommendations for such further program as may be necessary.

The Technical Board of the Society of Automotive Engineers requested the Gasoline Equipped Vehicles Advisory Committee to consider whether or not the problem of spark-plug fouling in automotive engines was a suitable subject for cooperative work in the CRC. The members of the Committee agreed that the spark-plug problem was being worked on by a number of companies, and no benefit would accrue from cooperative work on this specific problem in the CRC. They did, however, suggest that combustion-chamber deposits and their effect on engine performance and octane requirement was a more general and extensive problem, involving both the engine manufacturers and the petroleum industry, and was suitable as a CRC project. It was indicated that solutions to the problem were directly competitive and therefore not suitable as a CRC project, but that an evaluation of the seriousness and extent of the problem and the development of research techniques for the study and evaluation of factors involved in the problem were definitely the types of activity CRC should be doing.

The Group on Full-Scale Field Service Tests of Railroad Diesel Fuels of the Diesel Fuels Division is continuing its work on the Patapsco and Back Rivers Railroad, using Baldwin switcher locomotives, and on the Lehigh and New England, using American Locomotive Co. road freight equipment. It is anticipated that this program may be expanded to include the testing of fuels that may be supplied during an all-out emergency.

The DFD Group on Effect of Sulfur on Engine Operation prepared a comprehensive laboratory test program which was discussed at length by the CRC Assignment Committee and the Diesel Fuels Division. At these meetings, the desirability of conducting the project at this time was questioned by some, because of the increased demand on laboratory personnel and equipment caused by the military emergency. It was decided that the question should be referred to the members of the Internal Combustion Engine Institute who had previously indicated their intention of participating in this program, to see whether or not they still approved the program, and would participate in view of the current manpower situation and other conditions. At this time, it seems as if this program may be put aside in favor of more urgent work.

The DFD Ignition Quality Testing Group has prepared a calculated cetane index alignment chart, with an attachment outlining its limitations. A paper based on the work of this Group was presented to the World Petroleum Congress in May, 1951, on behalf of the CFR.

An overall report on the work of the Bureau of Mines on the constant-volume combustion bomb has been prepared, and will be available for circulation shortly. The 1951 cooperative program consists of two concurrent investigations.

1. A program to investigate the effect of fuel composition on combustion behavior in the bomb.
2. A program of specialized testing to investigate the effect on combustion of operational and equipment variables.

The Bureau of Ships, Department of the Navy, has supplied the Diesel Fuels Division with a list of some of the Navy's current problems and investigations in connection with diesel fuels in order to permit proper consideration of military problems in planning future programs. These problems include a quantitative evaluation of the degree to which deposits and wear are affected by undesirable fuel constituents and certain engine operating conditions; an evaluation of the effects of the various constituents and properties of diesel fuel on starting, warmup, and power performance under winter and arctic temperatures; salt-water corrosion; storage stability and compatibility; a study of cetane number improvers and fuel-type starting aids; and a study of the significance of cetane number. An Assignment Group has been organized to consider these problems and prepare a research program, if one seems to be indicated.

The Aviation Fuels Division is now applying all its efforts to projects involving gas turbine fuel adaptation, and the only active piston engine project which it had under investigation, the project on induction system deposits, has been transferred to the group working on fuel stability problems.

The AFD Gas Turbine Vapor Lock Group has prepared a comprehensive report on the vapor-locking characteristics of gas turbine fuels. This report covers a large number of tests to explore the variables which influence the vapor formation and fuel losses in high-performance gas-turbine-powered aircraft, using a mockup of an aircraft fuel system. The Group's studies included the effect of vapor formation on fuel pump operation and the evaporation and liquid entrainment losses from the tank. The conditions for the test were chosen to accentuate differences among fuels within the range covered by present-day aircraft.

The outstanding effect that was found to be different from any previous experience was the large quantity of foam which is formed when JP-3 type fuels are climbed rapidly. These entrainment losses were affected by vapor space in the tank, by the rate of climb, and by tank pressurization. However, they appear to bear no simple relation to fuel properties. Evaporation losses, exclusive of the foam, were in reasonable agreement with CRC formulas previously developed for aviation gasoline.

The Group on Low Temperature Pumpability of Gas Turbine Fuels is continuing its program on

full-scale airplane fuel systems at the Thompson Products Laboratories in California, and a project is under way to develop a laboratory research technique which will predict low-temperature pumpability of turbine fuels. Tests are being conducted on 1/20th-scale equipment which has been checked to insure correlation with full-scale equipment, and an extensive program is under way.

The Group on Combustion Characteristics of Gas Turbine Fuels is also proceeding with its work on the development of a test or tests which will provide significant and relatively simple means of evaluating the combustion characteristics of gas turbine fuels.

Lubricant and Equipment Research

The Coordinating Lubricant and Equipment Research Committee has about nine major projects under active investigation, with seven additional in the preliminary study stage.

The cold weather project being carried on for the Ordnance Corps is being continued on a standby basis, waiting for field reports from Alaska.

The study of lubrication requirements of Ordnance vehicles is continuing. An extensive field service test of a series of high-additive-content oils has been completed and a comprehensive report will be issued shortly. At present a second series of tests is being carried out by the Ordnance Corps, using oils of the general MIL-0-2104 type, but the CRC activity is concerned principally with the requirements of the Ordnance aircooled tank engine. Preliminary tests gave contradictory answers, and groups of engines are being tested at both the Detroit Arsenal and at Aberdeen Proving Ground to establish the extent of any difficulties.

The reproduction of engine deposits and wear in the laboratory similar to conditions found in actual field operation is the objective of one of the CLR projects. Considerable progress has been made using a number of engine designs, piston-ring combinations, and operating conditions.

The study of airframe lubricants and bearings is being carried on for the Air Development Force and progress has been made in the high-temperature operation and rust prevention phases. Arrangements have been made to obtain service requirement data and service testing, which have been lacking in the past.

At the request of the Air Development Force, a CLR Group has designed bearing test equipment which can be made available to industry for the development and testing of improved bearings and lubricants. This program was initiated because of the inability of the bearing manufacturers, with their limited scale of aircraft bearings, to carry out development programs which are necessary.

The Ordnance project on protection in storage of military equipment has been expanded to cover the problem of short-time storage which has been brought on by the military emergency.

In accordance with a request received from the Air Development Force, an extensive program has been initiated to study the use of compounded lubricating oil in reciprocating aircraft engines. Flight service tests will be conducted by the Air Force on a series of oils in B-36 and B-50 aircraft. These service data will be made available to the members of the CLR Aircraft Reciprocating Engine Lubricant Performance Group, who, using such research techniques as are made available, will attempt to establish a series of techniques, covering such items as spark-plug fouling, preignition tendencies, and so on, which will correlate with the field service data.

Future issues of SAE Journal

Will contain complete editorial coverage in . . .

October: 1951 SAE National Tractor Meeting and Production Forum

November: 1951 SAE National Aeronautic Meeting, Aircraft Production Forum, and Aircraft Engineering Display

December: 1951 SAE National Transportation Meeting

1951 SAE National Diesel Engine Meeting

1951 SAE National Fuels and Lubricants Meeting

Temperature Extremes Complicate Lubrication

REPORTED BY

E. A. Droegemueller, Pratt & Whitney Aircraft, Division of United Aircraft Corp.
D. N. Harris, Shell Oil Co., Inc.

• Round table on Lubrication Problems of Aircraft Powerplants was held at SAE Summer Meeting, French Lick, June 6, 1951, under the auspices of the SAE Aircraft Powerplant Activity. Discussion leader was D. H. Harris.

LUBRICATION of exhaust valve guides is the major lubrication problem with present high output piston engines. The R-4360, where operated at high cruise power, is encountering serious trouble with the development of oil coke in the exhaust valve rocker box. This coke not only interferes with valve action, but particles of coke break loose and cause clogging of oil drain lines, spray jets, and essential oil passages.

The operating temperatures of the valve stem and guide are high enough to cause decomposition of any present-day non-compounded petroleum oil with the presently used oil flow rates. Flooding the rocker box with oil appears to be a means for reducing the guide temperature, and higher flow rates seem to reduce the oil residence time and flush away decomposition products. Initial airline experience with this approach appears promising.

Additive oils of the type used in automotive and diesel engines are generally excluded from the large, high output aircraft engine because of preignition and bronze exhaust guide corrosion at the elevated temperatures which exist. Carefully selected additives must therefore be used. Tests are underway to evaluate several of these oils as to the improvement possible by this approach to the rocker box problem. Results to date are promising although the thought was expressed repeatedly that it is doubtful if oils can be a complete cure unless valve operating temperatures are reduced.

Full-flow oil filters capable of removing the finely divided particles present in the oil are impractical because of the high oil flow rates involved. Service experience with bypass type filters indicates that while the solids content of the circulating oil may be reduced, engine cleanliness does not appear to be significantly improved.

More frequent oil drains appear to increase trouble with plugged oil screens and passages, and engine cleanliness does not appear to be appreciably improved. The industry appears to be pretty well agreed that "no oil drains," except at engine overhaul, is the preferred practice. It was pointed out that this same policy may not apply to additive oils, and extensive service experience with these oils will be required before the optimum drain period will have been established.

Increasing engine overhaul periods has introduced problems with wear of vibration dampers, shaft splines, accessory drive gears, and similar parts of the engine. Oils having improved anti-wear properties for these parts would be of assistance in improving engine service life.

Turbine Engines—The turbine powerplant imposes a new set of requirements for the lubricating oil, and the range of operating conditions presents some real problems with the lubricating oil.

Satisfactory starting and immediate full-load operation requires that the oil flow at - 65 F or lower if possible. Generally, 5000 cs is considered the maximum oil viscosity which will permit satisfactory starting; thus the oil should not exceed this

Continued on page ~~63~~ 68

E. A. Droegemueller (left) served as secretary and D. N. Harris as moderator of the Summer Meeting Round Table discussion they report in the accompanying article

> WE know better but we forget.
>
> We have the knowledge to design complex aircraft, build them, and maintain them; but still we have occasional failures resulting from slips in applying some principle every engineer knows.
>
> The reminders and examples following are presented to refresh the memory of designers, shop men, and maintenance engineers in all phases of the aircraft industry—or any industry.

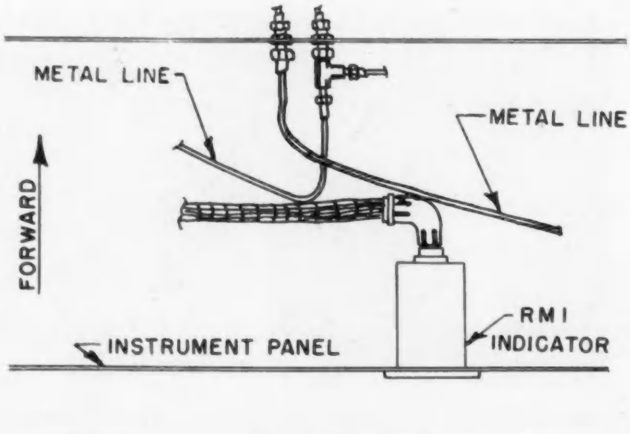
Reminders

REMINDER: Allow for adequate clearance between parts which should not interfere.

LAPSE: A new-type, longer navigational aid instrument was installed in the pilots' instrument panel of one airplane. Clearance was determined to be adequate. So the instruments were installed in other airplanes of that model, without thorough consideration of movement of the panel on its shock mounts, effect of worn shock mounts, differences between fleet aircraft, and manufacturing tolerances.

RESULT: In one airplane, one line wore through from rubbing against the electrical plug connection and another line wore through from rubbing against the electrical cable from the same plug.

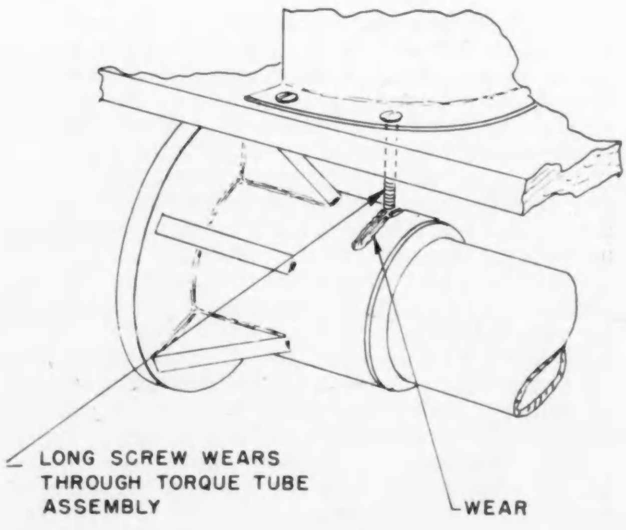
CORRECTION: Consider all possible spatial relationships and provide clearance accordingly.



LAPSE: The guard covering the cut-out provided in the cockpit floor for control column clearance was secured by screws through the floor.

RESULT: Too long a screw was used in one case, so that the screw damaged the torque tube.

CORRECTION: On existing aircraft, establish maximum length of screw permissible and require inspections to make sure that screw is not in contact with tube. On new aircraft designs, locate screws so that long screws can not interfere with the torque tube or incorporate fasteners which do not project beneath the floor board.



on Detail Design

BASED ON PAPER BY

W. W. Davies, United Air Lines, Inc.

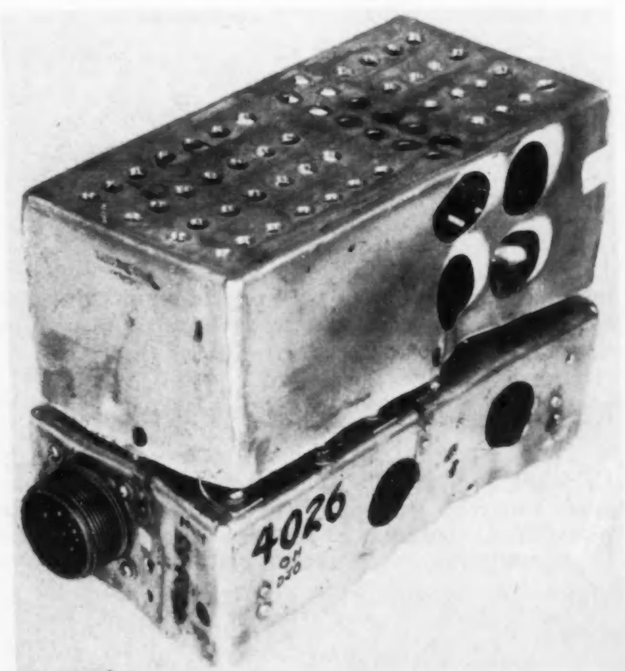
• Paper "Treatise on Experience—Review of Some Detail Design Experiences" was presented at SAE National Aeronautic Meeting, New York, April 16, 1951. Complete paper is available in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.

REMINDER: Design for handling in service.

LAPSE: The housing for an electronic control designed to be quickly removable was welded together out of soft aluminum sheet. The cover was secured with spring steel clips and rivets.

RESULT: The housing was badly battered from normal service handling.

CORRECTION: New covers were made of aluminum alloy with positive cover fasteners.

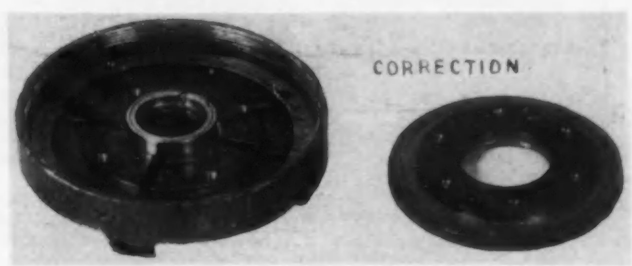


REMINDER: Use dissimilar materials for mating bearing surfaces.

LAPSE: Dural was used in contact with dural as bearing surfaces in the clutch of an autopilot trim tab servo installation. The clutch acts every time the autopilot servo is engaged and serves as a slip clutch when the servo is overpowered. This clutch is the only means of disconnecting the servo from the tab system. Its bearing surface operates at all times when the servo is disengaged.

RESULT: Severe galling occurred, requiring decommissioning of all autopilot equipment for correction.

CORRECTION: Steel bushings were used in the clutch housing and a bronze plate and bearing in the friction disc assembly.



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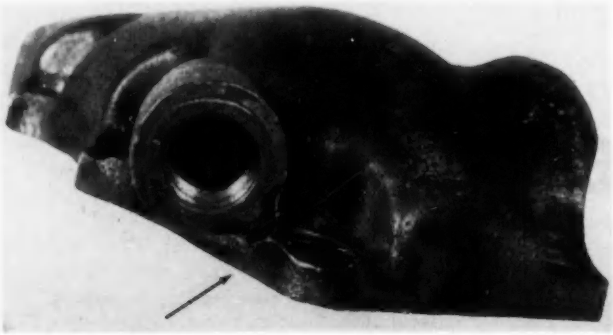
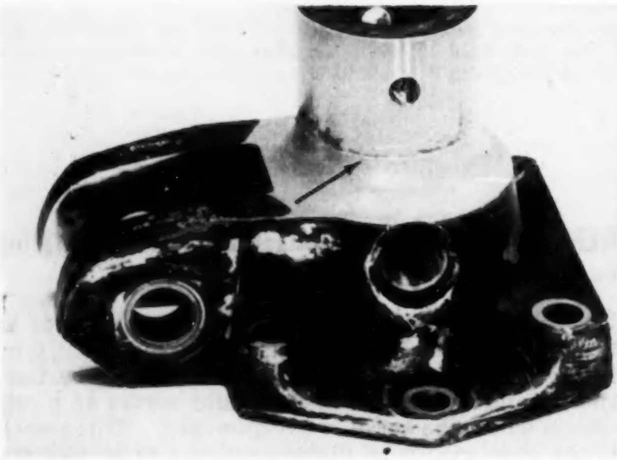


REMINDER: Avoid sharp edges.

LAPSE: Bosses and attaching nut surfaces are spo
faced on the cast aluminum alloy rocker box cove
of a radial engine. Sharp corners created by th
spot facing operation have been left unrelieved.

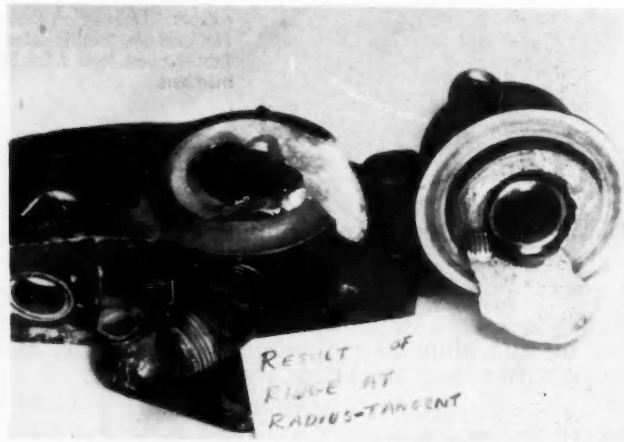
RESULT: Fatigue cracks originated at the shar
edges.

CORRECTION: Blend the sharp corner by re-machining with an oversize spotfacing tool havin
a generous corner radius—or by hand scraping t
break the sharp edges.



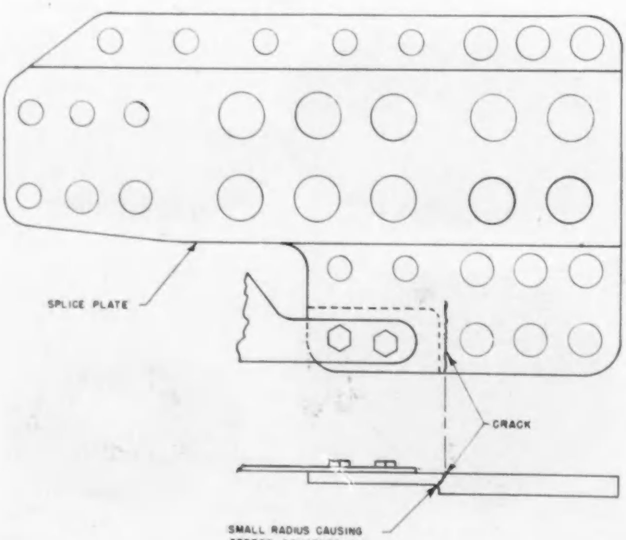
REMINDER: Blend radii to their tangents smoothly.

LAPSE: The radius was not machined accurately tangent to the journal of a landing gear fitting. This fitting acts as pivot for the rotation of the gear and carries the main load into the airframe.



RESULT: The fitting failed, letting the landing gear collapse.

CORRECTION: On existing parts, replace parts having inaccurate juncture. For future production, machine radius to meet journal smoothly.



REMINDER: Use adequate fillets.

LAPSE: Too small a radius was used at a cut-out machined in a splice plate to accommodate mating structure. The plate secures spar cap and landing gear fitting.

RESULT: The splice plate failed at the radius.

CORRECTION: Plates already installed on aircraft must be inspected frequently and replaced when they show signs of failure. Larger radii must be machined on replacement plates.

Automobile Seats Perform Important Safety Function

REPORTED BY

E. R. Langtry, Ford Motor Co.

• Round Table on Automotive Seating was held at SAE Summer Meeting, French Lick, on June 4, 1951, under the auspices of the SAE Body Activity. Discussion leader was E. C. Pickard.

WAYS for automobile seats to better perform their important safety functions were explored extensively at this round table by the engineers, suppliers, and users present. Also described during the discussions were practical tests for checking seat cushion quality on a production basis; current equipment to determine life expectancy, and static and dynamic characteristics of cushion springs; coil spring constructions developed in recent years; features of zig-zag spring construction; and the basic requirements of a good fibrous pad.

Automotive seats perform an important safety function in the operation of a passenger car. Whether or not an impending accident takes place often depends on (1) proper seat positioning of the driver so that he has adequate visibility and ready access to the mechanical controls, and (2) the physical condition of the driver. He must not be so fatigued by the seat that his perceptions are dulled, his mental reaction time increased, or his muscles stiffened.

Extreme driver fatigue is usually evidenced by pain, cramps, numbness, and stiffness—partially caused by shock forces applied to the body during car motion. These forces can be reduced by the use of softer or lower rate springs. The low limit of rate is set up in part by the amount of space available for deflection.

One speaker stressed the increased danger for the passenger and mentioned the current use of soft crash pads and possible use for hand rails or safety belts. Rear cushion bolsters are presently being used in taxicabs to minimize the possibility of passenger injury during rapid decelerations. But, from recent passenger car experience, it is apparent that safety belts and rails are not acceptable to the general public.

A development engineer explained that these features are conducive to driver fatigue:

1. Seating posture—controlled by seat back angle and cushion rake

2. Excessive local pressure—eventually resulting in hard spots

3. Instability—which brings on fatigue by making the driver fight to keep himself in a fixed position

4. Lateral and vertical vibration

The loaded contours of a seat are of great importance in determining proper cushion and back angles. Both of these angles are relative and neither have been standardized.

Cushion length is tied to back softness and also should be considered in terms of loaded contours. Front and rear cushion lengths are not standardized because of the different requirements in various body styles. However, free cushion length in front seats is quite close throughout the industry.

Good fatigue characteristics and good show room feel are both desirable but, unfortunately, these qualities do not necessarily go hand in hand and compromises must be made. Furthermore, the seat engineer faces the problem of providing a satisfactory seat—for people with a wide variety of physical dimensions—where location of control pedals, steering wheel, floor and roof have been predetermined.

Practical tests suggested for checking the quality of seat cushions on a production basis are (1) simple load-deflection tests, and (2) contour checks. A

Listening to Moderator E. C. Pickard of Ford Motor Co. open the Automotive Seating Round Table are (left to right): J. C. Gordon, Gordon-Chapman Co.; (Pickard), J. D. Caton, Stubnitz-Greene Co.; and H. E. Chesebrough, Chrysler Corp.

fatigue testing or bouncing machine is used to obtain information on seat cushion life.

Test equipment now permits determining the life expectancy of a cushion spring. Pressure distribution and dynamic characteristics can also be measured. A time-deflection fixture is used to check damping, velocity and acceleration characteristics of seats and their components. Electronic equipment makes this checking operation extremely accurate.

A spring manufacturer pointed out that several combinations of coil spring construction have been developed in the past 15 years. One of these is the four-row coil with helical cross ties, with accommodations for added coils to stiffen the seat and raise the eye level. Another is the flexible beam construction with coils on top, which results in more foot room for the rear seat passenger. The trend toward use of conventional or open coil type springs was attributed to high cost and scarcity of burlap.

Features of zig-zag springs units were reported to be:

1. Less material needed
2. Manufacture by automatic machines
3. Lower shipping and handling costs
4. Less storage required
5. Elimination of spring sub-frame
6. Negligible service expense

Lack of service complaints indicate that the pub lic has accepted this type seat from a ride stand point. However, work is done to vary seat frequenc and it has been found that by varying the pitc of the zig-zag wire in local areas, the frequenc can be changed.

The basic requirements of a good fibrous pad ar many and varied.

1. It should not sag between zig-zag springs o cup between coil springs.
2. It must have the ability to yield to compressio and have a minimum amount of elasticity in bot length and width. However, it must be partiall elastic to prevent fractures in the pad.
3. It should have a reasonably safe rate of recovery to keep permanent set in the trimme cushion to a minimum.
4. It must be uniform throughout with regard to thickness, density, and compression rate.
5. It must possess smoth top surfaces to avoid a rough or bumpy seat cushion or back.

The padding has the direct responsibility in presenting to the prospective automobile buyer, particularly to women, a seat which compares favorably with upholstered living room furniture. Show room feel is of utmost importance and is directly dependent on the quality of the seat padding.

TEMPERATURE EXTREMES COMPLICATE LUBRICATION

Continued from Page 63

viscosity at the minimum desired starting temperature.

Operating oil temperatures can be controlled and maintained at levels which will be satisfactory from an oil deterioration standpoint. However, upon engine shutdown the heat stored in the turbine wheel, blading, and other hot parts soaks into the shaft bearings, which with some engine models will reach a temperature as high as 450 F. Decomposition of the oil during this shut-down soak period may cause failure of the bearings upon restarting the engine.

At the reduced ambient pressures which exist at high altitudes, the evaporation rate of the lubricating oil is greatly increased. Present mineral oils are causing difficulty due to rapid loss of oil supply by evaporation and the problem will become acute as operating altitudes are increased.

Turboprops require adequate oil film strength for the reduction gears. Development of low viscosity oils for easy starting with adequate film strength is complicated by the wide variety of metals and seals present which must not be corroded. Also, accepted laboratory test methods are not now available to the industry for evaluating the film strength of experimental oils.

The Air Force reported instances where jet powered fighters suffered complete loss of oil due to enemy action and are now investigating the mechanism by which the resulting engine failure occurs. It is hoped that provisions can be included in the engine-oil design which will permit the engine to be operated for 15 to 20 min, after oil supply is lost, before complete engine failure results.

It was the concensus that the requirements of the turbine engine will necessitate the development of synthetic oils not now generally available if the ultimate development of the engine is not to be seriously impaired.

Fig. 1—The B-47, a swept wing jet bomber, first large airplane in the world of this type

High Overall Performance Obtained on Jet Bomber

EXCERPTS FROM PAPER BY

Robert M. Robbins and William H. Cook, Boeing Airplane Co.

• Paper, "Flight Characteristics of the Boeing B-47 Stratojet," was presented at SAE National Aeronautic Meeting, New York, on April 18, 1951.

PRINCIPAL purpose of the experiment development of the Boeing B-47 Stratojet was to prove that: (1) high overall performance could be obtained in jet bombers, (2) flight characteristics would be satisfactory for tactical use.

Early design studies showed that performance goals could best be obtained with a swept wing design, using six currently available engines. Fig. 1 shows the B-47 in flight. It has a high aspect ratio wing for long range. Six engines in nacelles are arranged to give minimum influence on wing limiting speed, low fire vulnerability, and easy access for maintenance. This engine arrangement is also designed to have favorable effects on stalling characteristics, flutter speeds, and longitudinal stability.

The main goal of the program was to prove out the swept wing jet bomber, first large airplane in the world of this type. Initially, the project was not aimed at developing many minor items to a point of maximum effectiveness, minimum weight and simplicity. Such extraneous developments, having little to do with the overall airplane, might delay the primary program for considerable time. Therefore, the attitude was adopted that positive control would be obtained over all flight characteristics, even at the expense of some mechanical complication.

Control surface operation has always been a problem. Due to the unknowns with control surface hinge moments at high Mach numbers, all three controls are operated by irreversible hydraulic servos with artificial pilot feel and centering. If

Fig. 2—Flaperon provides lateral control for cross wind landings by partially retracting the outboard section of the flap

there is a failure of the power control, emergency operation is provided through conventional cable controls, assisted by internal aerodynamic balancing. Done properly, this combination gives a pleasing impression since the airplane appears to be very maneuverable with minimum control effort.

Stalling characteristics were supposedly bad on swept wings. Since no time was available for flying scale models, careful attention was given to wind tunnel tests. These determined the design of airfoil sections and slats, and demonstrated the importance of proper nacelle location. The large dihedral effect of swept wings at slow speeds also was shown to be a possible source of difficulty, particularly on cross wind landings. The solution was use of a powerful lateral control with flaps down. Fig. 2 shows the flaperon which provides this control by partially retracting the outboard section of the flap as "up" aileron is called for on that side.

Another special design arrangement affecting the flight characteristics is the tandem, or bicycle landing gear—chosen after numerous studies of internal arrangement. Neither jet nacelles nor the wing were big enough for a main gear which would carry the load of the B-47. Therefore, a gear retracting within the body was necessary. (A tricycle gear meeting this requirement had several disadvantages. It made for poor internal arrangement, and the tread would be narrow—giving poor protection to the wing tips.) Fig. 3 shows the attitude of the B-47 on the ground. The aft location of the rear gear affords increased protection to the tail and wing tip in a nose high landing, while the wide tread of the outriggers provides good lateral stability.

The many new design features called for unusually extensive pilot training and other unique preparation to improve safety on the first flights. Initial jet engine familiarization was obtained on a gas turbine, mounted below the bomb bay of a B-29. Additional familiarization with jet engine and airplane operation was accomplished by flying F-80's. Take-offs using JATO bottles were a part of this program.

The typical flat landing approach of jet airplanes is, to a large extent, the result of high idling thrust of jet engines and lack of propeller windmilling drag. In addition to F-80 experience, this characteristic was simulated on several landings in a B-29. (This was done by having the co-pilot operate the engines at the proper rpm with the propellers in fixed pitch to give the same thrust as the jet engines. Partial flap extension was used to simulate the stalling speed of the B-47, and essentially the same weight and braking were available.) It was found important that correct approach speeds be maintained, and that by so doing emergency landings could be made on moderate length fields. At this time neither the drag parachute nor anti-skid device had been developed.

The low speed characteristics of the elevator and rudder were investigated in a wind tunnel with a set of tail surfaces from one of the experimental airplanes and a short afterbody. Fig. 4 shows the "Iron Monster" installation in an NACA 40×80 ft wind tunnel.

The pilots found operation with the power con-

Fig. 3—Attitude of the B-47 on the ground. Location of rear landing gear affords increased protection to tail and wing tip in nose high landings. Wide tread of outriggers provides good lateral stability

rols smooth and light, and emergency operation—with power controls inoperative—heavy but adequate.

To this actual experience was added considerable familiarization with the B-47 systems, performance, emergency endurance and range procedures. With the conclusion of the thorough ground and taxi tests, the pre-flight training was complete. Flight characteristics were found to be as expected, although different in some ways than on past bombardment types.

The handling characteristics will be presented as they would appear to a pilot, experienced in multi-engine operation, who has also flown jet airplanes and is ready for checkout in the B-47.

Cockpit

The cockpit resembles a fighter because of the canopy and tandem seating arrangement. The pilot has exceptional visibility over the nose and on both sides, as well as above and aft. Flight controls are conventional and have the large mechanical advantage required for emergency operation with power-servos off. The throttles are clustered together on the right stand for easy grip by one hand. The instrument panel has the standard flight group and also the instruments for the six engines. The fuel panel is of the diagrammatic type, with gages, valves, and warning lights functionally indicated and located on the diagram.

First impressions may be that the pilot is impossibly overburdened by six engine operation. However, several factors show this to be otherwise. Each jet engine is operated by only one lever affecting power, as against four controls on the usual reciprocating engine-propeller combination. In addition, the two or more controls on various cooling air outlets are all absent on jet engines. Standard systems have been designed to require a minimum of attention. Examples are a comparatively simple fuel system, flap retraction and extension speeds consistent with the airplane's requirements, minimum longtitudinal trim changes, and light stick forces for easy one hand operation of the flight controls.

The co-pilot has a similar arrangement and also has control of the electrical system, emergency landing gear and flap, and other equipment normally not requiring operation. His seat is elevated over the pilot's to improve vision.

Taxiing

The B-47 is very easy to taxi. After it is started rolling by a short period at moderate power, idling thrust is sufficient for taxiing. Turning at low speeds can be made about very short radius and is accompanied by a noticeable "heeling over" sensation. Steering is accomplished entirely by a steerable nose wheel, controlled by the rudder pedals. At moderate taxiing speeds the pilot can roll the airplane slightly with the ailerons, compressing the soft outrigger oleo struts.

Take-Off

The take-off is accomplished in a normal manner. Pre-run up of engines is not necessary, as a power check can be made during the first part of the roll. With the large fore and aft spread of the tandem gears, the pilot has virtually no control over the

Fig. 4—Low speed characteristics of the elevator and rudder were investigated in a wind tunnel

attitude on the ground which was selected for optimum take-off speed under emergency conditions. Take-offs are made with full flap. At the unstick point the airplane flies off the ground with the elevator near neutral. This entirely satisfactory arrangement prevents the pilot from varying the unstick speed—frequently done improperly when he can rotate the airplane on the ground.

One important point on take-off is the comparatively long ground runs necessary, particularly on hot days. This is due to the constant thrust characteristic of jet engines, and the fact that the great power of the jet engine in flight permits high airplane loadings. However, once in flight things get better in a hurry.

During cross wind take-offs a large amount of aileron control is required to keep the B-47 laterally level. In addition, the drift of the airplane at speeds appreciably below take-off speed is very noticeable because of the difference between the airplane's heading and track down the runway.

In general, the feel of the B-47 on take-off is very similar to that of a flying boat.

Climb Out

After take-off the gear is retracted, followed by the flaps. The speed of flap operation matches the accelerating characteristics of the airplane. During flap retraction, a retrimming device prevents any change in trim so that no longitudinal trimming is required until best climbing speed is reached. Particularly appreciated on a refused landing is the negligible effect of power changes on trim.

One new characteristic of jet airplane is the very high speed for best rate of climb and high maximum rate of climb. Terrain permitting, this results in a low angle climb during acceleration, followed by

a steeper and more rapid climb to the high altitudes desired for cruising. When required for clearance reasons, steeper angles can be obtained at the expense of efficiency by holding the speed down since engine cooling is not a problem.

Maneuvering Characteristics

Means for providing the artificial control feel were designed to give the characteristics of "ideally aerodynamically balanced controls." While ideally desirable to give the pilot light controls for easy handling—yet heavy enough to protect the airplane structure from excessive loads—this cannot be achieved without questionable compromise. However, with artificial "feel" the forces can be set to suit the majority of pilots without a tailoring flight test. The new pilot will find the forces on the B-47 pleasantly light. Normal control coordination is required. Rates of roll are particularly evident to the pilot because the aileron forces are very light, the only force being that required to achieve centering. The controls are so smooth and light that the airplane can be easily flown "down the alley" in buzz jobs and demonstrations.

Rough Air Stability

The characteristics of an airplane in rough air tend to have more influence on a pilot's opinion than some of the more spectacular phases of flight. One of the characteristics of swept wings is the load relieving tendency of the wing tips. The unusual flexibility of the B-47 wing is shown in Fig. 5, which is a composite photograph taken during positive and negative wing static load tests. The wing tip travelled 17½ ft between the two conditions. This wing flexibility is quite apparent in rough air. Pilots can see the wing tips and outboard nacelles "riding the bumps" while the cockpit is riding smoothly. When talking to pacer airplanes, B-47 pilots have found that they were obtaining considerably smoother rides than their companions in the stiff winged fighters. This characteristic results in a more stable bombing platform.

Longitudinally, the B-47 is very much less disturbed by turbulence than non-swept wing bombers. Damping of the longitudinal motion following a gust is high, with no visible "short period" oscillations. Laterally, the plane is much more disturbed by gusts. Whereas, many conventional airplanes have a yawing oscillation following a side gust, the higher dihedral effect of swept wings causes a coupled rolling objectionable to pilots. By applying a small corrective motion to the rudder, using a "yaw damper," those oscillations can be damped as well or better than in straight winged airplanes. Use of this control is optional; nothing is required from the standpoint of safety.

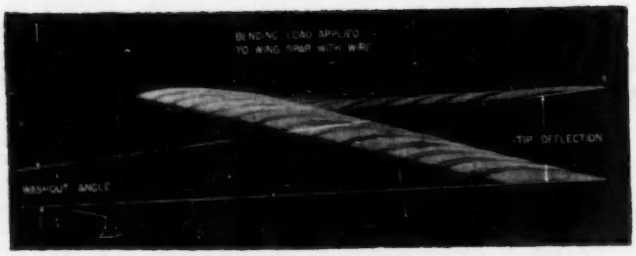


Fig. 5—Unusual flexibility of swept wing tips give smoother riding qualities under rough air conditions

Fig. 6—Drag parachute "saves" many otherwise impossible landings

Stalls

Straight wing airplanes often have an abrupt stall, due to the whole wing "letting go" at once. This undesirable condition rarely exists on a swept wing where some sections hold on for a long time. Stall warning on swept wings is usually more pronounced, with a wider speed band. Thus there is little excuse for inadvertent stalls on the B-47.

Most large airplanes which do not limit the amount of elevator control have rolling tendencies in the extreme stall. This is also true on the B-47. However, powerful lateral control is available. And in stall tests the pilot was able to hold the wings level by rapid control movements, the wing getting down to 30 deg in very few instances. During an extreme stall there is so much buffeting in the B-47 it is hard to conceive of this small amount of roll having any practical significance. Pitching in a full stall is mild. No loss in altitude occurs on approaches to stall warning when followed by proper recovery. A large loss in altitude does, of course, occur on complete stalls, as is true on all heavily-loaded airplanes.

Because of the good stalling characteristics that exist without wing slats, they are being eliminated on production airplanes. This will save approximately 600 lb and simplify maintenance and manufacture. The slats are typical of one of the features incorporated so that positive control of the airplane's characteristics would be assured. This feature proved unnecessary.

Approach And Landing

Rapid descents from altitude are made with the landing gear down. The flaps are put full down in the landing pattern. On final approach the pilot must maintain the desired airspeed to avoid using excessive amounts of runway and to maintain an adequate margin over the stall. One disadvantage of the tandem gear is that the speed range in which smooth landings can be made is more limited than on other types. The airplane cannot be landed at a speed much higher than that for simultaneous contact of both gears. Touching the front gear first with an appreciable rate of descent will result in a bounce back up in the air, or will at least prevent enough load being applied to the wheel to permit effective braking. Usually on contact the pilot releases a drag chute. This device, shown in Fig. 6, will "save" many otherwise impossible landings. In addition to the parachute an anti-skid device has been developed which gives more consistent stops, with far less tire wear, under all conditions.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

BODY REQUIREMENTS

For Military Tactical Wheeled Vehicles

EXCERPTS FROM PAPER BY

Capt. J. L. Quinnelly, Ordnance Corps, Detroit Arsenal

• Paper, "Military Tactical Wheeled Vehicle Body Requirements," was presented at SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 6, 1951.

BODY designers must meet unique requirements in designing bodies for military tactical wheeled vehicles.

Vehicle size is a most important consideration. In these days of airlifts and seaborne invasions, door sizes of planes and ramp openings of landing barges limit overall dimensions, especially height and width. Any accessories or kits required, such as spotlights, ventilators, or heaters, must not increase these overall dimensions.

Some dimensional limitations are governed by the particular use to which the vehicle will be put. For example, the length of an ambulance is fixed by the length of a standard army litter. Loading height is also critical, since supplies or ammunition may have to be loaded by men standing on unfavorable footing.

The question of materials is a thorny one. It is highly desirable to reduce weight to a minimum for the sake of air transportability. But, in a national emergency, wheeled vehicles are not on a priority list for lightweight materials. Therefore, bodies are designed for steel construction. And in the event steel becomes unavailable, manufacturers must be capable of switching to wood construction for the floor. (All-wood bodies have not proved satisfactory.)

Trucks through the 2½-ton class have to be strong enough structurally to withstand airdrop by parachute. Cargo bodies which accommodate palletized loads must be able to support the materials handling equipment used to load and unload them.

Equipment must operate satisfactorily in a wide range of temperatures (-65 F to 125 F). In this connection, the present trend for artic operation is to install high-output personnel heaters in the cargo body and to replace the tarpaulin with quilted fiberglass.

Appearance of vehicles is important but not in terms of distinctive styling. On the contrary, it is desired that vehicles used for command purposes do not have a distinctive silhouette.

The vehicle must present a clean overall appearance. Various holes and knock-outs often seen in the sheet metal of some cabs are a necessary exception to this rule. These provide the means whereby personnel and powerplant heaters and deep fording units can be mounted in the field with minimum time, manpower and tool requirements.

Ease of maintenance is another postwar requirement receiving increased attention. This affects a number of features of body design. Specifications call for hinging the hood at the rear to provide better accessibility to the engine compartment with lifting devices, employed during powerplant removal. Grilles must be hinged to fold forward on some types for the same reason.

Body designers must keep in mind various kits which may be applied to the vehicle and which the body must be capable of accepting. Some of these kits and their requirements are:

1. Deep water fording—requiring provisions for air intake and exhaust stacks, together with brackets and supports for the stacks.
2. Winterization (calls for hard-top, personnel and powerplant heater kits)—requiring holes and knock-outs for mounting.
3. Utility for converting the ¾-ton cargo truck to a command vehicle—requiring a different tarpaulin, map table, radio installation, and necessary interior fittings.
4. Arctic closures for cargo bodies—consisting of quilted fiberglass tarpaulin, insulated floor, and personnel heater.
5. Ground mine protection to prevent injury to personnel from land mines.
6. Armored cab to replace the standard cab.

Military requirements call for both hard- and soft-top truck cabs, except for field ambulances which have cabs integral with the body. Present designs utilize a "convertible" type construction—doors and windows are furnished with the soft-top version, and a metal top replaces the canvas one. Windshields are required to be a folding-forward type, making the overall height reducible to the top of the steering wheel. (This cuts down shipping space.) It is also desirable that the windshield be placed vertically to eliminate light reflection and detection from the air. The seat covering, canvas top, and body tarpaulin must be fire resistant, mildew-proof, and removable for decontamination.

The interior of the cab must be free of sharp corners, edges, or projections likely to cause injury to operating personnel. And all controls must be capable of operation by personnel wearing heavy winter clothing.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

SAE National Aeronautic

Production Forum

Aircraft Engineering Display

Wednesday, Oct. 3

Aircraft Production Forum

Sponsored by SAE Production Activity

B. C. MONESMITH, Chairman
J. L. ATWOOD, Sponsor

Nine separate informal gatherings to exchange information and experience on vital aircraft production problems. Each discussion will be sparked by a panel of experts as listed below.

9:30 a.m. Registration Galeria

Registration Fee for Aircraft Production Forum and Technical Sessions:
Members, Applicants, Students and Service Men . . No Fee
Other Nonmember Guests . . $2.00

10:00 a.m. to 12:00 Noon—
2:00 p.m. to 5:00 p.m.
(Except Machining Panel starting at 9:00 a.m. and Forming Panel starting at 2:00 p.m.)
Room Locations to be Announced

INSPECTION

Covering organization — centralized versus decentralized (types of control); statistical application; first-article inspection methods; ratio of inspectors to direct workers for various types of work; rejection rates for various types of work and major categories of causes; tool and gage control.

Panel Leader
—B. W. CLAWSON, Quality Manager, Long Beach Div., Douglas Aircraft Co., Inc.

Panel Co-Leader
—R. C. LOOMIS, Manager, Quality Control, Consolidated Vultee Aircraft Corp.

Secretary
—W. F. STRYKER, Quality Control, Long Beach Div., Douglas Aircraft Co., Inc.

Panel Members
—L. B. ALLEN, Quality Control Manager, Solar Aircraft Co.
R. S. CATLIN, Director of Quality, Northrop Aircraft Co.
G. A. COVINGTON, Chief of Inspection, Consolidated Vultee Aircraft Corp.
I. DAGAN, Director, Quality Control, Rohr Aircraft Corp.
D. L. HEDGES, Director, Quality Control, Airesearch Mfg. Co.

ELECTRONICS—
Its effect upon aircraft production

Covering organizational tie-in; testing and inspection methods; specialized handling problems; personnel training.

Panel Leader
—C. W. CLARKE, Manager, Manufacturing Control, Airesearch Mfg. Co.

Panel Co-Leader
—E. M. BOYKIN, Supervisor, Field Engineering, Hughes Aircraft Co.

Secretary
—C. H. HANSEN, Public Relations Dept., Airesearch Mfg. Co.

Panel Members
—A. F. DuFRESNE, Director, Quality Control, Consolidated Engineering Corp.
H. E. HOSKINS, Assistant Supervisor, Field Operations, El Segundo Div., Douglas Aircraft Co., Inc.
J. H. OWEN, Foreman, Functional and Precision Assembly Dept., Lockheed Aircraft Corp.
MIKE WELSCH, General Foreman, Electronics Dept., Boeing Airplane Co.

MACHINING—9:00 a.m.

Covering special-purpose equipment; tapered sheets and integrally stiffened sections; stainless and super alloys (Hastelloy C, Inconel X, N-155, magnesium, titanium, etc.); cutting tools.

Panel Leader
—MICHAEL FIELD, Partner, Metcut Research Associates

Panel Co-Leader
—B. A. WILLSEY, Manager, Manufacturing Div., Solar Aircraft Co.

Secretary
—MALCOLM JUDKINS, Chief Engineer, Firth Sterling Steel and Carbide Corp., Carbide Div.

Panel Members
—S. N. BEAN, Chief Tool Engineer, Lockheed Aircraft Corp.
N. A. LOMBARD, Staff Assistant to General Manager, Santa Monica Div., Douglas Aircraft Co., Inc.
W. M. WILLIAMS, Chief Factory Engineer, Thompson Products, Inc.

FORMING—2:00 p.m.

Covering special-purpose equipment; deep drawing (types of dies); hot forming (75-S, magnesium); stretch forming.

Panel Leader
—O. A. WHEELON, Production Design Engineer, Santa Monica Div., Douglas Aircraft Co., Inc.

Panel Co-Leader
—J. S. CORRAL, General Foreman, Machine Forming, North American Aviation, Inc.

Secretary
—Miss D. M. OHME, Secretary to O. A. Wheelon.

Panel Members
—B. K. BUCEY, Tool Design Manager, Boeing Airplane Co.
G. E. LARSON, Tool Development Engineer, Northrop Aircraft Co.
G. F. RAYNES, Chief Tooling Engineer, Rohr Aircraft Corp.

PROCESSING

Covering welding (special alloys, welding equipment); metal bonding; ceramic coatings.

Panel Leader
—J. V. LONG, Director of Research, Solar Aircraft Co.

Panel Co-Leader
—C. L. HIBERT, Chief Process Engineer, Consolidated Vultee Aircraft Corp.

Secretary
—H. W. INGALLS, Patent Assistant, Solar Aircraft Co.

Panel Members
—L. E. FROST, Tool Engineer,

Meeting

Oct. 3-6, 1951

Biltmore Hotel, Los Angeles

F. W. Fink
General
Chairman
of Meeting

B. C. Monesmith
Chairman
Production Forum

J. L. Atwood
Sponsor
Production Forum

North American Aviation, Inc.
F. G. HARKINS, Welding Engineer, Solar Aircraft Co.
W. G. HUBBELL, Assistant Chief, Development Laboratories, Ryan Aeronautical Co.
EUGENE WAINER, Director of Research, Horizons, Inc.

PRODUCTION CONTROL

Covering shop loading and load forecasting; feeder operations and subcontracting; tabulating applications; scheduling (fabrication details and subassemblies).

Panel Leader
—E. F. GIBIAN, Chief Industrial Engineer, Thompson Products, Inc.

Panel Co-Leader
—A. C. WALLEN, Tooling Manager, Long Beach Div., Douglas Aircraft Co., Inc.

Secretary
—R. L. ANDERSON, Industrial Engineer, Long Beach Div., Douglas Aircraft Co., Inc.

Panel Members
—J. E. ADAMS, Director of Purchasing and Planning, White Motor Co.
F. W. LLOYD, Superintendent, Manufacturing Control, Northrop Aircraft Co.
W. F. SNELLING, Superintendent, Production Control, North American Aviation, Inc.

LABOR COST CONTROL

Covering performance measurement; indirect labor cost control; direct labor cost control.

Panel Leader
—H. W. THUE, Plant Manager, Santa Monica Div., Douglas Aircraft Co., Inc.

Panel Co-Leader
—R. W. RUBIDGE, Chief Industrial Engineer, Lockheed Aircraft Corp.

Secretary
—S. J. SULLIVAN, Office Manager, Santa Monica Div., Douglas Aircraft Co., Inc.

Panel Members
—W. J. CARRIGAN, Assistant to Comptroller, Solar Aircraft Co.
J. H. MADDOX, Manufacturing Control Manager, El Segundo Div., Douglas Aircraft Co. Inc.
P. J. PRESCOTT, General Supervisor, Schedules, North American Aviation, Inc.
L. C. WALGASH, General Production Manager, Continental Can Co.

TOOLING DEVELOPMENT

Covering plastic tooling; standard components; tooling mastering devices.

Panel Leader
—H. V. SCHWALENBERG, Chief Industrial Engineer, North American Aviation, Inc.

Panel Co-Leader
—C. S. GLASGOW, Chief Tool Engineer, Santa Monica Div., Douglas Aircraft Co., Inc.

Secretary
—J. A. MAURICE, Manufacturing Engineer, North American Aviation, Inc.

Panel Members
—R. E. BECHTOL, Chief Tool Designer, Consolidated Vultee Aircraft Corp.
A. KASTELOWITZ, Chief, Manufacturing, Research and Development, Republic Aviation Corp.
G. J. WALKEY, Manufacturing Research Engineer, Lockheed Aircraft Corp.

PLANT ENGINEERING AND PLANT LAYOUT

Covering economics of equipment repair versus replacement; preventive maintenance; plant layout policy; materials handling.

Panel Leader
—W. A. BURTON, Properties Manager, Long Beach Div., Douglas Aircraft Co., Inc.

Panel Co-Leader
—H. W. LINTON, Chief Methods Engineer, North American Aviation, Inc.

Secretary
—K. R. WALTZ, Plant Engineer-Supervisor, Long Beach Div., Douglas Aircraft Co., Inc.

Panel Members
—E. F. MELLINGER, Executive Assistant to Factory Services Manager, Ryan Aeronautical Co.
R. B. PARKHURST, Director, Production, Hughes Aircraft Co.
J. L. PETIT, Plant Engineer, Consolidated Vultee Aircraft Corp.

SAE National Aeronautic Meeting Program continued on next page→

SAE National Aeronautic Meeting Program

continued

Thursday, Oct. 4

9:30 a.m. Registration Galeria

Registration Fee for Technical Sessions:
Members, Applicants, Students and Service Men .. No Fee
Other Nonmember Guests .. $2.00

10:00 a.m. Ballroom

Welcome to Los Angeles

F. W. FINK,

General Chairman of Meeting

GEORGE MANGURIAN, Chairman

Design and Manufacturing Techniques with Titanium
—O. A. WHEELON, Douglas Aircraft Co., Inc.

Recent Developments in Sandwich Structures
—W. S. SAVILLE, Consolidated Vultee Aircraft Corp.

Adhesion Engineering
—SETH GUNTHORP, Consolidated Vultee Aircraft Corp.

(Sponsored by Aircraft Activity)

2:00 p.m. Ballroom

F. C. MOCK, Chairman

General Design Aspects of Turboprop and Turbojet Aircraft Fuel Systems
—C. S. BRANDT, Consolidated Vultee Aircraft Corp.

Symposium—Fuel Tank Explosion Protection

Report of Explosion Suppression Development
—J. ISREELI, Simmonds Aerocessories, Inc.

Summary of Combustion Studies for Generation of Inert Gas
—J. F. HILL, Surface Combustion Corp.

(Sponsored by Aircraft Powerplant Activity)

8:00 p.m. Ballroom

B. J. VIERLING, Chairman

Military Operations of Helicopters
—Lt.-Col. K. B. McCUTCHEON, U. S. Marines, Quantico
"Employment of Transport Helicopters in the Assault"—color motion picture

(Sponsored by Air Transport Activity)

Friday, Oct. 5

10:00 a.m. Ballroom

R. R. LaMOTTE, Chairman

Operating Characteristics of Propellers for Turboprop Airplanes
—J. M. MERGEN and J. H. KASLEY, Propeller Division, Curtiss-Wright Corp.

Installation Experience with Turbojet Afterburner Powerplants
—HAROLD ADRION, Chance Vought Aircraft Division, United Aircraft Corp.

(Sponsored by Aircraft Powerplant Activity)

2:00 p.m. Ballroom

R. D. KELLY, Chairman

High-Speed Pressure Refueling of Aircraft
—R. H. LEBOW, The Parker Appliance Co.

Some Developments for Improved Crash Safety in Aircraft
—R. J. SCHROERS, Civil Aeronautics Administration

(Sponsored by Air Transport Activity)

8:00 p.m. Ballroom

CLARK B. MILLIKAN, Chairman

Presentation of

DANIEL GUGGENHEIM MEDAL

to IGOR I. SIKORSKY

by P. R. BASSETT
Chairman, Daniel Guggenheim Board of Award

Trends in Air Force Research and Development
—Major-Gen. D. L. PUTT, Acting Deputy Chief of Staff, Development, U. S. Air Force

Trends in Navy Aeronautical Research and Development
—REAR ADMIRAL C. M. BOLSTER, Chief of Naval Research, U. S. Navy

Trends in NACA Research and Development
—HUGH L. DRYDEN, Director, National Advisory Committee for Aeronautics

(Sponsored by Aircraft Activity)

Saturday, Oct. 6

10:00 a.m. Ballroom

J. H. FAMME, Chairman

Flight Experience with the Vickers Viscount Turbo-Propeller Airliner
—G. R. EDWARDS, Vickers-Armstrongs Ltd. (Aircraft Section)

Aircraft Maintenance in Korea
—COL. T. J. NOON, Aircraft, Fleet Marine Force, Pacific

(Sponsored by Aircraft Activity)

Banquet and Grand Ball

7:30 p.m., Saturday, Oct. 6

Grand Ballroom

The Biltmore Hotel Los Angeles

SAE WEST COAST MEETING

General Chairman R. E. Fleischer (left), with Banquet Chairman Howard Lovejoy

Gives Guns-and-Butter Data

A NEAR-RECORD attendance of 376 engineers at the 1951 SAE National West Coast Meeting, Seattle, Aug. 13-15, packed into every technical session and debated every paper throughout three stirring days.

The guns-and-butter theme stressed by A. T. Colwell in an analysis of our current economy on the opening day ran through the meeting as a whole. Detroit Arsenal's Col. W. A. Call stuck entirely to the "guns" area with an up-to-the-minute story of what our Army needs in wheeled transport vehicles. But most others talked of technical matters applicable to keeping trucks and buses running and improving in operating efficiency. Predictions were made of engineering trends in many specific areas.

Operators heard, for instance, an oil technician's belief that high-additive oil is worth while in city operation, seldom needed in long lines service, and beneficial (particularly in preventing corrosion) in off-highway service. They learned that Kenworth's experimenters think commercial production of a turbine-engined truck is still five or ten years away. . . . And that Cummins' engineers believe "considerable development lies ahead before potential aspects of turbosupercharging are realized in diesel engines."

They got newly-organized basic facts about fuel and lubricant filters . . . learned that improperly matched tires can cause excessively high lube oil temperatures, which, in turn, can help cause failure in worm axle gears . . . and got new confirmation of many currently-believed ideas about the where and why of engine deposits. They heard that more field data are needed to solve the problem of how to match dual tires for maximum wear . . . and got a prediction from Perfect Circle's A. M. Brenneke and A. J. Weigand that chrome-faced oil rings are due for increasing use. They learned more, too, about the basic principles of axle design and construction.

Also, Portland Traction Co.'s Earl B. Richardson portrayed his "dream vehicle" for city bus service, relating it to results of extensive studies of the economics of present city transport systems.

A feature of this entire meeting was the high percentage of those registered who actually attended the technical sessions and participated in the discussions. Session attendance ranged from 175 to more than 200. The meeting was sponsored by the Diesel Engine Activity, the Fuels and Lubricants Activity, the Transportation and Maintenance Activity, and the Truck and Bus Activity. Northwest Section, host to the gathering, had the cooperation of the seven other West Coast Sections and Groups.

In opening ceremonies, SAE President Dale Roeder, Ford Motor Co., and SAE Secretary and General Manager John A. C. Warner welcomed the members and guests. Roeder was introduced by Roy T. Severin, chairman of SAE Northwest Section. At the dinner on Tuesday evening, George L. Neely, Standard Oil Co. of Calif., was toastmaster. C. M. Simmons, Simmons Institute of Human Relations, was the chief speaker. His subject: "Slow Leak—Beware!"

Talking of man's relation to his fellows in business and life, Simmons emphasized the importance of attitude. Results accomplished by an individual on

Among those at the speakers table were (left to right): F. O. Hosterman, Southern California Section chairman for 1950-51; SAE President Dale Roeder; E. W. Rentz Jr., SAE West Coast manager; A. T. Colwell, vice-president of Thompson Products, Inc.; John A. C. Warner, SAE secretary and general manager; and R. E. Fleischer, general chairman of the meeting

a particular job, he said, depend very largely on the attitude with which he approaches the task.

He urged more objective thinking; less subjective thinking. The path to accomplishment is made smoother and faster, he indicated, by thinking more of the other fellow; less of ourselves.

President Roeder, in a brief talk at the dinner, told of SAE's active participation in the defense effort through technical committee work for the military and stressed the importance of the automotive engineer in our guns-and-butter economy.

Arrangements for this most successful meeting were in the hands of a committee headed by R. E. Fleischer, Colyear Motor Sales of Seattle, as general chairman. Serving with him were R. C. Norrie, program chairman; Ray Snodgrass, arrangements chairman; Howard Lovejoy, banquet chairman; C. E. Johnston, financial chairman; Lee Ketchum, house chairman; E. C. Rawlings, registration and reception chairman; T. C. Howe, sight-seeing and transportation chairman; K. A. Short, publicity chairman; and Dan Cheney, field editor.

With R. J. W. Young as chairman, the Monday morning technical session was devoted to Col. W. A. Call's paper on "Military Wheeled-Transport-Vehicle Requirements." Chief of Development and Engineering at the Detroit Arsenal, Colonel Call pointed out that with commercial vehicle design, cost and sales appeal are of prime importance. (A feature article giving the highlights of Colonel Call's paper is scheduled for the October SAE Journal.)

Monday afternoon W. C. Heath chairmanned the technical session at which piston ring wear and turbosupercharging of high speed diesels were the topics.

Piston Ring Wear

A. J. Weigand and A. M. Brenneke of Perfect Circle, talking on piston wear, said that the greatest factor in piston ring wear is abrasive wear, especially top-groove and top ring-side wear. No complete solution has been found, but a number of innovations in the past 10 years promise improved results.

Chrome-faced oil rings seem to offer improvement in oil control. At least one engine manufacturer has adopted this type of ring, they said, and a multiple piece, inner-spring type chrome-plated oil ring is available in the aftermarket.

Cast-in groove inserts are now successfully bonded into aluminum pistons to retard the side wear of the top groove and top ring. Work is now being done to reduce the cost of such inserts, and the performance of plain cast iron inserts compares favorably with that of the costly Ni-Resist insert. Far too little attention has been given in the past, these authors said, to the microstructure and physical properties of cylinder materials.

The authors are in agreement with the recommendation of a 15 to 30 microinch finish with a cross-hatch pattern for cylinders.

In discussion following the Weigand-Brenneke paper, Charles Winslow asked: What is the minimum ring width for the top ring? A. In most cases 3/32 in.; in a few cases, 5/64 in. Q. What is the minimum width of the oil ring? A. Best is 5/32 in. Breakage and clogging mitigate against narrower widths.

Michael Guidon, University of Washington, asked: Is unit pressure on cylinder walls being maintained with narrower rings? A. Modern engines demand narrower rings to increase unit pressure due to higher compression ratios. There isn't much difference in the amount of wear. Q. Is there an empirical solution available to determine the number of rings? A. No.

In another question from the floor, Weigand was asked what ring combination would best tend to lessen blow-by. A. All engines require some blow-by. Q. Are manufacturers taking advantage of the better oil-holding qualities of porous-chrome? A. No. Porous chrome wears and causes wear. Q. What is the best way of breaking in new rings? A. Use normal operating conditions, but don't overspeed. Q. What is your experience with additive oils during break-in period? A. Good. A compounded oil is fine for breaking in.

Rings aren't made to fit cylinder distortions, Weigand said, and use of Bon Ami to help seat rings was held to be inadvisable. Rings don't have enough

earance for grit, he continued, adding that the best ing to do is to correct the cylinder wall distortion y honing, reboring, or sleeving.

N. M. Reiners and W. D. Schwab of Cummins Diesel titled their paper "Turbosupercharging of High Speed Diesel Engines." They discussed the application of the turbosupercharger to high-speed automotive diesel engines. Turbosuperchargers have long been used to improve the fuel economy and maximum power output of large engines operating at substantially constant speeds and loads. Considerable development work must be done, however, before this type of supercharger can be successfully applied to automotive diesels, which must operate over a wide range of speeds and power, with flexibility and smoke-free operation over the complete operating range.

Initial development work in applying this type of supercharger to the $5\frac{1}{8} \times 6$ in. Cummins 200-hp (naturally aspirated) high-speed diesel produced the following results:

1. Output was raised to 339 hp with the turbosupercharger, as compared with 300 hp when supercharged with a Roots blower.
2. Full-load performance characteristics of the turbosupercharged engine at low engine speeds were not as satisfactory as for the Roots-supercharged engine. There is some evidence that certain gains could be made with a higher-capacity turbosupercharger. It appears feasible, therefore, that, by further development on matching of the turbosupercharger to the engine plus, possibly, modification of the engine-fuel rate characteristics, a satisfactory performance curve could be obtained on the turbosupercharged engine.
3. Increasing the intake air temperature can seriously decrease the maximum power output of a turbosupercharged engine if the increase in air temperature necessitates a reduction in the fuel rate to avoid exceeding the maximum exhaust temperatures allowed by the turbosupercharger or the engine.
4. Because of the limited rate of acceleration of the turbosupercharger the required air/fuel ratio for commercially acceptable exhaust smoke cannot be obtained on the turbosupercharged engine under all dynamic operating conditions.

In a written discussion of the Reiners-Schwab paper, W. E. Woollenweber and M. L. Land of Elliott Co. said in part:

"Experience with low speed diesels shows that the open combustion chamber gives optimum combustion and scavenging characteristics when supercharged with a turbocharger, and it is to be expected that similar conditions exist in the case of high-speed diesels. . . . The turbocharger offers the only practical means of maintaining substantially sea-level output from an engine at high altitudes without recourse to some means of intercooling. . . . The acceleration problems encountered with the turbocharger are by no means new. The automotive application admittedly presents the most serious problems, but continued development will bring about steady improvement."

Canada in 1953 . . .

In 1953, the SAE National West Coast Meeting will be held for the first time in Canada. Site will be Vancouver, B. C., with the SAE British Columbia Section as host.

In 1952, the meeting will be in San Francisco, with the SAE Northern California Section as host.

The Economic Picture

Tuesday evening, A. T. Colwell's subject was "The War Mobilization Situation and Its Effect on the West Coast Transportation Industry." On page 82 of this issue appear excerpts from this interesting analysis by the vice-president of Thompson Products. F. O. Hosterman was chairman at this session.

At the Tuesday morning session two papers were heard—one on engine deposits and the other on fuels and lubricants filtration, P. J. Favre was in the chair.

On engine deposits, R. S. Spindt and C. L. Wolfe of Mellon Institute came to these conclusions:

1. Gasoline does contribute to, and, under some engine conditions, may be the chief cause, of induction system, piston, and crankcase deposits.
2. The nature of intake valve deposits and the degree of burning may be a function of gasoline type as well as of operating conditions.
3. The character of combustion-chamber deposits is far more important than their amount when the adverse effect on preignition and octane requirement increase is considered.
4. The lubricating oil is probably the medium through which the deposit-causing agents from the fuel travel to form engine deposits. These deposits are probably not laid down on the piston as the

Delegates from Spokane-Intermountain Section were (left to right): James H. Ray; E. N. Klemgard; Peter J. Favre, 1950-51 Section chairman; George A. Jackman; Dwight Hume, 1951-52 Section vice-chairman; and Harold C. Besgrove, 1951-52 treasurer

Among out-of-towners at the meeting were (left to right): L. A. Christensen, Crown Zellerbach Corp.; J. Verne Savage, Oregon Section past-chairman; Nicholas Buchanan, General Petroleum Corp.; Clarence Bear, 1951-52 Oregon Section secretary; and Prof. W. H. Paul, 1951-52 Oregon Section vice-chairman for Students

blowby migrates from the combustion chamber to the crankcase.

5. Low jacket temperature is conducive to deposit formation. Raising the jacket temperature appears to prevent their formation but does not reduce oil contamination. Oil contaminants will deposit out on any engine surface that is at the proper temperature. Piston deposits already formed cannot be removed by increasing the jacket temperature.

6. Addition of the correct type of detergent to the oil will reduce deposits originating from the fuel. The deposits studied were of the type and amount that could be controlled by the detergents.

7. Complex diolefins and aromatic olefins, as well as other special types of compounds, appear to play a major role in the formation of these deposits. Simple paraffins and olefins do not seem to enter into deposit formation.

Filters

Charles A. Winslow, Winslow Engineering Co., was the speaker on filtration of fuels and lubricants for internal combustion engines. He said that a most important consideration with lubricating oil filters is just where they should begin, and where they should leave off, in preventing the circulation of particles through bearings. In general, he explained, all particle sizes less than the minimum bearing clearances are of small importance, providing they are eventually trapped out of the system during operation.

Fuel oil filters present an entirely different problem to the filter designer. Sudden or unexpected stoppage of fuel, causing engine shutdown, is the major problem here. All deleterious material and particle sizes that might damage the injection equipment must be removed at one pass, since no recirculation is generally provided.

On Tuesday afternoon, evaluation of bus requirements for city service and progress made with Kenworth's turbine test truck were the topics. Lyle Garnas was chairman.

City Bus Needs

E. B. Richardson of Portland Tractor Co., making the talk on city bus requirements, said that city bus companies need a new bus. To successfully provide public transportation at reasonable rates, he explained, their dream vehicle must be reasonable in first cost, operate economically on fuel, and be simple and rugged enough to prevent excessive service and maintenance labor costs. Among the basic requirements he outlined for the perfect vehicle were:

1. Use of light weight materials in chassis and body construction;
2. Clean, smooth body lines—clear of all embellishments;
3. Interiors that lend themselves to a minimum of vandalism;
4. Proper step heights, door opening widths; and grab rails, safe treads, and aisle floor coverings—all conducive to passenger safety;
5. Reduction in the number of gadgets—unless they can be made foolproof, rugged and reliable.

Turbine Truck Progress

R. C. Norrie, of Kenworth Motor Truck Corp., reported on the turbine test truck developments. He said that development of the gas turbine engine as motive power for heavy duty trucks has progressed to the point where the engine is now ready for the military services.

Engine reliability has been measurably improved and gains have been made in fuel consumption. However, before commercial operators will be satisfied, the replacement and repair of certain parts—now measured in hundreds of hours of engine life—will have to be measured in thousands of hours of engine life. . . . And fuel consumption, which still runs between three and four times that of a diesel engine burning identical fuel and hauling the same gross load, will have to be improved.

In the discussion following the Norrie paper, the following questions were asked and answers given:

Q. Why is a five-speed transmission used in the turbine-powered truck? A. (Norrie) There is a need for a wide range of speed to meet varying road and load conditions. At the same time it is necessary to permit the turbine to operate within its efficiency range. Therefore we use a five-speed transmission in the test truck to balance the unit.

Q. How does the engine perform with Bunker C? A. (W. Skidmore, supervisor of testing, turbine project, Boeing.) We have done some work with Bunker C. It is in the cards. The cost is about one-fourth that of diesel, but we must preheat the oil for satisfactory flow and have encountered trouble with impurities.

O. D. Treiber, consulting engineer, Hercules, pointed out that the weight/time factor must be considered rather than the weight of the powerplant alone. He pointed out that fuel load is as

much a part of weight as engine load. Norrie responded that the factor of weight/time has been considered and is not too unfavorable at this point.

Discussion brought out that temperatures in the nozzle box are around 1500 F and at the exhaust stack around 1150 F. Combustion efficiency is 98 to 99%. Richard Tanzola, Los Angeles heavy-duty truck operator, asked when the engine will be ready for commercial use. A. Possibly five years, maybe 10.

Total horsepower developed by the 502 turbine, Skidmore said, is 475 to 500 hp, but about 300 hp is consumed by the air compressor.

The concluding technical sessions were on Wednesday morning and afternoon. C. H. Lewis presided in the morning; E. J. McLaughlin in the afternoon.

Tires

Tires were discussed in both the morning session papers. Under the title "Why Dual Tires Do Not Stay Matched," H. M. Place of U. S. Rubber said that dual tires do not stay matched because of the conditions of road crown and axle camber which are imposed on them. These factors cause unequal rolling radii of the two tires and produce a "fight" between them, since they are trying to turn at the same rate and cannot. This tension is relieved by slippage of the tire with the least load, resulting in a smaller diameter of that tire. The amount of wear on this tire is reduced by the greater "growth" of the more heavily loaded tire.

It was pointed out that either increasing the inflation or putting a slightly larger tire on the inside position will reduce the scuffing of the outer tire. However, both of these practices increase the load on the inner tire and thus tend to reduce its life.

Fleet operators were urged to keep records on tire behavior so that more data could be added to the general fund of tire information.

In a written discussion following the Place paper, Hoy Stevens, of American Trucking Associations, Inc., referred to his own past experience in a study of heat blowouts which showed that nearly 90% of the blowouts were on inside dual tires.

J. R. Schmitt, Standard Oil of California, told of the effect of tire mismatching on lube performance and maintenance costs of worm final drives. He said that mismatched tires can impair lubrication and increase wear of dual-drive worm gears. For example, if the tires on the front rear axle have longer circumferences or better treads, that axle will do more work than the rear rear axle. The more work done, the higher the lubricant temperature. If temperatures climb high enough to "cook" the lubricant, it no longer does its job and the gears will eventually fail.

Best practice is to have all the driver tires in the same condition of wear. Where this is impractical, the best compromise is to match tires on the left side of the front rear axle to those on the left rear rear axle—and the same for the right sides. The differential can take care of slight left-right differences between tire circumferences.

In the afternoon on Wednesday, N. R. Brownyer of Timken-Detroit Axle talked on "Final Drives for Commercial Vehicles" and J. A. Edgar, Shell Oil Co., on high additive oils.

Brownyer pointed out that three types of gear carriers (single-speed single reduction, single-speed double reduction, and two-speed double reduction) are interchangeable in the same housing of a new family of Timken axles. Built around the principle of interchangeable gear carriers and use of the same axle shaft in any given capacity unit, this new line of axles incorporates many innovations.

High-Additive Oils

Edgar said that high-additive oils are generally worth their added cost in city and off-highway operations but are needed infrequently in long-lines service.

In city service, high-additive oil positively prevents oil-ring plugging and reduces bore wear by half or more, thereby extending overhaul periods greatly.

In off-highway service, high-additive oil neutralizes the corrosive acids of combustion. The acids have much less chance of corroding the bore, so the bore wears longer. Fouling is lessened, too.

For long-lines service, only in the rare engines that show serious bore wear and fouling is use of high-additive oil justified.

Among points brought out in discussion following the Edgar paper were the following:

L. J. Grunder, Richfield, recommended investigation of the fluorescent method of oil analysis in addition to the blotter test.

From the floor: Is the spot check sufficient? Is it a scientific method of engine oil analysis? A. The blotter test is a good test. It is a scientific test, which, applied systematically, can be of great value, but it cannot replace chemical and physical analysis. Soot load and viscosity should be measured, too.

Weigand of Perfect Circle urged the oil people to tackle the problem of top groove and upper cylinder wear. Subsequent discussion attributed most of this wear to abrasion, pointing to a need for improved air cleaners and filters to reduce the admission of abrasive contaminants in the combustion chamber.

Two prominent Los Angeles fleet superintendents at the West Coast Meeting: James W. Sinclair of Union Oil Co. of Calif. (left) and Calvin T. Thomas of General Petroleum Corp.

Transport Industry Outlook Confused In Projected Guns-and-Butter Economy

EXCERPTS FROM PAPER BY

A. T. Colwell, Vice-President, Thompson Products, Inc.

• Paper, "The War Mobilization Situation and Its Effect on the West Coast Transportation Industry," was presented at SAE West Coast Meeting, August 13, 1951.

MODERN warfare is the most complicated phenomenon on the face of this globe. A close second is preparation for defense while attempting to maintain a complete peace economy, which is the task America has undertaken. In time of war, guns took precedence over butter, but never before in time of peace have we attempted a full supply of guns and butter at the same time.

Some materials are shy for the two programs.

One other problem is cost of materiel. The increased cost of military equipment is due to the far greater use of specialized equipment, such as electronic installations, plus the lowered buying power of the dollar, and is shown in the following comparisons:

Planes	Price at War's End	Latest Price
Fighter plane	$ 53,000	$ 218,000
Medium bomber	185,000	2,500,000
Big bomber	629,000	3,500,000
Transport plane	85,000	514,000
Heavy transport plane	260,000	1,800,000
Tanks		
Light tank	39,652	126,029
Medium tank	47,339	200,000

How the present dual program of guns and butter will affect the motor transportation industry can only be estimated by judging its importance in our national economy and what segments are absolutely essential.

When will stockpiling be appreciably reduced? Due to world conditions, will the defense program be stretched out? Will much of our military equipment be obsolete by the time our present program is completed, necessitating replacement? Does Stalin intend all-out war? Definite answers to such questions would greatly simplify the problem of predicting our economy over the next decade.

Highway Transportation

Statistics are dry and often uninteresting — and incorrect deductions can be made from them. For instance, a survey was made which indicated that Princeton men had an average of 1.4 babies, whereas Vassar women averaged only 1.3. It was therefore reasoned that men have more babies than women. In another case near Seattle there were one hundred men and two women in a logging camp. A man and one of the women were married, and the foreman briefly reported to the home office that 1% of the men had married 50% of the women that day. These statistics were temporarily of considerable annoyance to the home office. However, in studying the highway transportation picture, we cannot avoid using statistics.

Transportation is the life blood of a nation, and our national progress would have been impossible without it. Each type offers greatest utility in some field, and all are important. In the United States, 75% of the tons of freight moved are hauled in trucks (or truck-trailers, used synonymously with trucks in this paper). And 89% of farm produce is first moved by truck.

Any industry expands and grows only if it serves the public well, and one industry replaces another only if it does a better job. Highway transportation does both, and its growth has followed, as shown in Fig. 1.

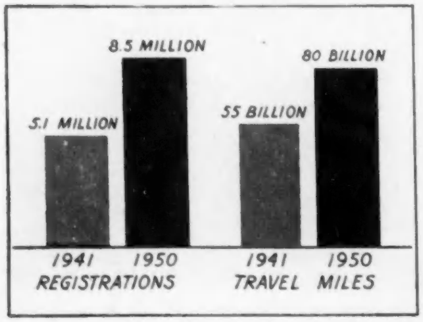


Fig. 1—66% Increase in truck fleet since 1941

Highway transportation industries employ over nine million persons, accounting for one out of every seven American jobs.

This is three times as many people as employed by all the railroads, airways, waterways, and pipeline systems combined. Further, it indicates that the really big business begins after these vehicles leave the factories, as only about 900,000 are employed in the manufacturing companies.

Future Outlook

In 1941 there were about 5,100,000 trucks on the road, increased to 8,500,000 in 1950. The greatest period of increase in trucking has been that since the end of the war.

There is no dispute as to the importance of the trucking industry, or of buses, or a large percentage of passenger cars. The difficulties arise when there isn't enough material available to meet all the demands of the entire problem: defense, stockpiling, scrappage and service—which is the situation we are entering into at present. Decisions must then be made regarding precedence in importance as of that moment, and such precedence may change from month to month.

The logical method of handling such a vast program is for some agency to know what material is available, what the demand is for each material, and what categories should take precedence in allotting the various materials. This is a colossal program, which will be subject to inertia and confusion in being implemented, at least for the first six months. Only time and events will indicate to what extent controls must be exercised, and how the overall plan will work.

In many cases substitutions can and must be made, which will allow more production than otherwise possible. SAE committees are actively at work on substitute materials for various purposes. Peculiar facts appear in some situations. For instance, because of normally higher volume, more total alloying materials are used in low alloy steels than in the higher alloy steels. And it is more difficult to procure carbon and low alloy steels today than the higher alloys.

New trucks and automobiles are continuing to be produced during the last half of 1951. These quotas have been set as follows for the third quarter, and the fourth quarter will be substantially the same:

Trucks	Light	150,000
	Medium	90,000
	Heavy	35,000
	Trailers	15,454
Autos		1,200,000
Buses		2,500
Trolley coaches		275
Truck and school bus bodies		104,000

The average truck life is 10½ years. Today about 2.4 million trucks are over 10 years old. This presents problems of replacing old vehicles, about 800,000 a year being needed, and of increased service requirements of the older trucks. Regarding buses, there

about 85,000 in operation at the present time and present quotas allow approximately a ten-year-life replacement program.

World and economic events will guide future allotments. In some quarters it is held that steel supply will be ample by late 1952. Sales volume of automobiles has dropped sharply, probably due to the scare buying of the past year. There has likewise been a drop in physical volume of replacement parts and accessories all over the country. Dollar volume is up slightly, but physical volume is off, and collections are slower.

As of today, the Motor Vehicle Division in Washington is thinking along the following lines on service parts:

1. Keep vital transportation in operation.

2. No service priorities at retail level, but attempt to keep the pipelines full by giving permission to parts makers to make 112% of base period (all of 1950, in dollars).

3. Parts to be a B product like common components (come off the shelf).

4. If service parts become scarce, attempt to raise the percentage of base period.

5. If material conditions become tight, stop producing non-functional parts (such as fenders), and use substitute materials.

6. Let vehicle and parts manufacturers use their judgment in setting up schedules for replacement parts.

7. Keep equipment operating in the following order of importance:
   (a) Heavy trucks, buses
   (b) Truck trailers
   (c) Automobiles, taxicabs
   (d) Light trucks

The outlook for service items is fairly good, although some tightness may develop in both high alloy and low alloy steel parts. The outlook for tires is good—the rubber situation has improved materially. Spare tires are now available again. Batteries are likely to be in shorter supply due to the lead situation. The 24-volt systems coming into military use require considerably more lead than the 12-volt systems. Copper at the moment is becoming a short item because of greatly increased use and stockpiling. This is true of many other materials.

Allocations have their good and bad points. Under the present DO ratings and "free" market, confusion has been widespread, with no certainty that schedules could be maintained. Under CMP, less material may be allotted, but the manufacturer will know definitely what his schedule can be.

Passenger car manufacturing will likely come under CMP in the fourth quarter this year, which may reduce output but will stop the present scramble in the "free" market. Material allocated for replacement parts in the third and fourth quarters is ample—in the fourth quarter on a basis of 570-million dollars of manufacturers' sales.

In general there should be no shortage of replacement parts for essential transportation, excepting spot shortages of specific parts which are bound to occur. However, there are indications that in the third quarter CMP has allotted raw materials beyond the supply. This situation probably will be corrected as the plan begins to function, but there may be some shortages in the third quarter.

The industry will undoubtedly cooperate where controls are necessary, but will look forward to the day when they can be withdrawn.

Gasoline octane numbers have shown a slight drop, due to the stockpiling of lead.

In case of total war there will be far more drastic rationing than in World War II, and octane numbers will drop appreciably. The fuel will be worse in relation to the engines of today, because of the increase in compression ratios.

Rationing is not foreseen unless there is total war, but the closing of the Iranian oil fields could bring on an acute fuel crisis for a limited time.

In World War II, 65% of our tonnage of military shipments overseas were petroleum products. For every ton of bombs dropped on Germany during the war, ten tons of petroleum products were needed to sustain the air attack. Our airforce will need much more fuel than in the last war. Farm mechanization, home heating, and the vast expansion in automotive use have kept the petroleum industry hard put to meet all needs. In another war, the military may need 5½ million barrels a day, or 2½ times what they used in the last war. Civilian uses inevitably must suffer, for modern war cannot be waged without oil.

Summary

1. The next six months will likely be the most confused portion of the defense program.

2. New cars and trucks and buses will continue to be made during the rearmament period, and likely in case of all-out war, but in reduced volume. Under the present DO rating system, many items are now difficult to obtain in the "free" market, but passenger car manufacturing is expected to come under CMP in the fourth quarter.

3. Service parts will be supplied to keep essential transportation moving in the listed order of importance.

4. Gasoline is not likely to be rationed during defense, but quality will be lowered somewhat, due to stockpiling of lead. In case of all-out war, fuel rationing will be drastic and the quality will drop. The Iranian situation could temporarily upset present planning on fuel, as our allies are supplied from those fields.

5. The rubber situation is now satisfactory for the defense program.

6. Steel should ease during 1952 if there is no all-out war.

7. Batteries may be short because of the lead situation. The 24-volt system in military equipment calls for increased amounts of lead.

8. Copper is short due to increased usage and stockpiling. This could affect the output of automotive vehicles.

9. Aluminum is tight at present.

10. Intensive work is being done to find satisfactory substitute materials.

11. When stockpiling is considered adequate, many materials will again be available for civilian use, which should be not later than 1953.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price 25¢ to members, 50¢ to nonmembers).

Dynamometer for Engine Friction Studies

Based on paper by

J. B. BIDWELL

and

W. H. SMITH

General Motors Corp.

THIS paper presents a description of developments in dynamometer equipment prompted by the need to make accurate and reliable power measurements in engine friction studies.

Details are given regarding hydraulic scales, sealed capsule hydraulic balance, torque measurements, horsepower meter, dynamometer cradle bearings, and calibration and testing equipment. (Paper, "Some Developments in Dynamometer Equipment," was presented at SAE National Passenger Car, Body and Materials Meeting, Detroit, March 8, 1951. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

C. E. McTAVISH, formerly vice-president of Perfect Circle Co., Ltd., Toronto, has been appointed president of that company. He will continue his duties as general manager. McTavish, a well-known figure in the automotive field for the past 35 years, was chairman of SAE Canadian Section in 1946-47.

HAROLD R. BOYER, a director of production engineering for General Motors Corp. since 1946, has been named deputy administrator for aircraft production of the Defense Production Administration. Boyer will be in charge of the nation's military aircraft program.

JOHN G. WOOD, formerly chief engineer of GMC Chevrolet Motor Division, has been appointed consultant to Aircraft Production Board of the Defense Production Administration. He will work with **HAROLD BOYER** (see above) on problems of the expanding aircraft engine program. Wood retired from Chevrolet in January, 1950, and for the past year has been a consultant on industrial conservation for the National Security Resources Board and DPA.

L. F. SHOEMAKER has been elected vice-president of Buda Company, Harvey, Ill. Shoemaker has been with the company for 31 years in various capacities, most recently as engine sales manager.

VERNON E. HENSE has been appointed chief metallurgical engineer for GMC Buick Motor Division, succeeding **ROBERT B. SCHENCK,** who recently retired. Hense was formerly assistant chief engineer for Buick. He will also replace Schenck on SAE Iron and Steel Technical Committee Panel C.

B. I. ULINSKI has been appointed director of engineering for Automatic Transportation Co., division of Yale & Towne Mfg. Co., Chicago. Ulinski, who was formerly chief engineer of rider-type electric industrial trucks, will be responsible for the management of all engineering functions at Automatic, including research, product design, test engineering and special engineering services. He has been with the company since 1918 in various capacities.

WALTER L. LULI, formerly chief engineer for the Twin Coach Co., Kent, Ohio, now holds the same position with the motor coach division of White Motor Co., Cleveland, Ohio.

About

DONALD D. ARNDT has been appointed general sales manager of Marvel-Schebler Products Division of Borg-Warner Corp., Decatur, Ill. Arndt was previously assistant general sales manager.

CHARLES L. SMYTHE, district sales manager of Cleveland Graphite Bronze Co., has resigned from that company and will resume his former real estate activities as vice-president of A. B. Smythe Co., Cleveland, Ohio.

DAVID E. MORRIS has been appointed assistant zone service manager for Nash Motors Division of Nash-Kelvinator Corp. in Atlanta, Ga. Morris was formerly district manager for the company.

TURNER A. DUNCAN, formerly assistant to the president of ACF-Brill Motors Co., has been appointed vice-president in charge of engineering for that company. **FRANCIS W. KATELY,** who was chief engineer, has been made vice-president in charge of engineering.

JOHN C. ANNESLEY is now district sales manager of Aluminum Co. of Canada, Ltd., Toronto, Ontario. Annesley was previously assistant general sales manager in the company's offices in Montreal, Quebec.

VON D. POLHEMUS has been named to head the GMC engineering staff structure and suspension development group, now located at the new General Motors Technical Center. Polhemus has been with the group since 1937, and prior to that had been with GMC's Cadillac Division since 1933.

CHARLES H. KUTHE, who was formerly associated with United Bronze Corp., has been named manager of the product development department of Wolverine Tube Division of Calumet & Hecla Consolidated Copper Co., Detroit.

FULLER F. BARNES, president of Associated Spring Corp., has announced the opening of a new plant by the Barnes-Gibson-Raymond Division of that company at Plymouth, Mich., replacing the old Detroit plant.

Members

HANNES A. RUESCH is now a designer of automatic controls with Landis and Gyr Co. of Zug, Switzerland. Ruesch was previously with National Automatic Tool Co. in Detroit.

HAROLD J. HUTCHINS, civilian deputy, aircraft division, division of maintenance engineering at Air Force Headquarters in Washington, has been appointed maintenance engineering representative on support problems of the B-47 aircraft task group.

RALPH B. WITTMAN, formerly with Curtiss-Wright Corp. at Caldwell, N. J., is now a research engineer for Grumman Aircraft Engineering Corp., Bethpage, N. Y. He will be engaged in flutter and vibration analysis.

ROSS CLEMENT LOVINGTON, who was an instructor in mechanical engineering at the University of Wisconsin, has taken a position with General Electric Co. in Richland, Wash.

JAMES E. DIMMETT is now with Rockwell Mfg. Co., Pittsburgh, Pa. Dimmett was previously an experimental test engineer for Pratt & Whitney Aircraft Division of United Aircraft Corp., East Hartford, Conn.

GEORGE E. MURRY, formerly with Fleck Oldsmobile Co., Bismarck, N. D., is now a tune-up and diagnosis mechanic with Birdsall & Stockdale Motor Co. in Colorado Springs, Colo.

PAUL G. HOFFMAN will be the principal speaker at the twelfth anniversary dinner of Automobile Old Timers, the first ever held in Detroit, at the Hotel Book-Cadillac on Oct. 4.

DONALD BLANCHARD, staff secretary, SAE Technical Board, will attend the Lighting and Signaling meeting of Technical Committee 22 on Automobiles of the International Organization for Standardization in Switzerland, Sept. 24–29. He is making the trip at the request of the Engineering Advisory Committee of the Automobile Manufacturers Association, at whose request the American Standards Association accredited him as the representative of American industry.

FREDERIC C. WEYBURNE, general manager of Marshall-Eclipse Division, Bendix Aviation Corp., Troy, N. Y., has been elected vice-president of the Friction Materials Standards Institute.

BYRON F. CAMPBELL has been appointed executive engineer for Harry Ferguson, Inc., of Detroit. Campbell has been with Ferguson six years. He is a member of SAE Tractor Technical Committee and of Iron and Steel Technical Committee Panel C.

PAUL RIBANYI is now research engineer with the Boeing Airplane Co., Seattle, Wash.

ROY HUMMEL has been appointed assistant to **B. H. SIBLEY**, factory manager of Champion Spark Plug Co., Toledo, Ohio. Hummel joined Champion in 1947. Prior to that he was plant manager of the ceramic division of B. G. Corp. of New York.

KARL W. GALLIGER has been appointed director of engineering of the hydraulic division of the New York Air Brake Co., Watertown, N. Y. Galliger has been with the company since graduating from Clarkson College of Technology in 1941, but from 1942 to 1945 was on military leave of absence to serve with the United States Army Engineers in Europe.

ARTHUR E. RAYMOND, vice-president in charge of engineering of Douglas Aircraft Co., Inc., will deliver the 39th Wilbur Wright Memorial Lecture at Brighton, England, on Sept. 10. His talk on "The Well-Tempered Aircraft" will be a feature of the Anglo-American meeting of the Royal Aeronautical Society and the Institute of the Aeronautical Sciences. Raymond served as president of the Institute in 1946, and was elected 1949 Honorary American Fellow of the Institute.

DUNCAN B. GARDINER has been appointed assistant chief engineer of Vickers, Inc., Division of Sperry Corp. Prior to the appointment Gardiner had been chief product development engineer since 1944, after serving as a product engineer in the company's industrial, navy, and aircraft divisions for a total of 16 years.

WILLIAM H. HARRIS, JR., has been elected vice-president in charge of engineering of Micromatic Hone Corp., Detroit. Harris has been with Micromatic for 16 years, most recently as chief engineer.

C. B. VEAL, former secretary and manager of the Coordinating Research Council and now a consulting engineer, has moved his headquarters to 208 Sperling Boulevard, Tarpon Springs, Florida. When he reentered consulting practice in 1947, Veal returned to a field of automotive engineering in which he first began to work in 1902. Prior to his years with CRC, he was SAE Research Manager and, prior to 1921, a partner in the firm of Manly & Veal, consulting engineers.

CHARLES D. STRANG, JR., formerly research associate with the lubrication laboratory of Massachusetts Institute of Technology, has joined Kiekhaefer Corp., Cedarburg, Wis., as director of research. Strang is currently visiting major engine and automobile factories in Europe and Great Britain for his new company.

WALTER S. PRAEG, president of National Broach & Machine Co., Detroit, is now in Europe attending the first European Machine Tool Exhibition in Paris, and plans later to visit principal gear companies in Great Britain and Europe. He is accompanied by **BEN F. BREGI**, executive engineer of National Broach & Machine Co.

STUART B. HAESSLY, formerly chief engineer at Donaldson Co., Inc., St. Paul, now holds the same position at Crenlo, Inc., Rochester, Minn. Haessly is membership chairman of the Twin City Section.

WALLACE E. WHITMER, is now on active duty with the U. S. Navy. He holds the rank of lieutenant and is stationed aboard the U. S. S. Bottineau. Prior to this, he was with the Truck & Coach Division, GMC, Pontiac, Mich.

NORMAN G. SHIDLE is author of "Clear Writing for Easy Reading" recently published by McGraw-Hill Book Co., New York. It tells how to get ideas off a page into a reader's mind. It describes and teaches a specific method for writing papers, articles, letters, memoranda—or any kind of writing which attempts to explain, to sell, or to influence its readers. Shidle is editor of SAE Journal and Manager, Publication Division, SAE headquarters staff.

L. W. SILLCOX, executive vice-president of New York Air Brake Co., was commencement speaker at the graduation ceremonies of Lawrence Institute of Technology on June 12. Earlier in the year Sillcox spoke at the graduate school of business administration of Harvard University on the subject of the diesel electric locomotive.

J. DOUGLAS CATON, previously employed by Chrysler Corp., Detroit, as a seating engineer, is presently vice-president of The Stubnitz Greene Spring Corp., Adrian, Mich. He is engaged in sales development and engineering.

GEORGE E. ZORINI, formerly a lubrication engineer in the Indiana Division of Phillips Petroleum Co., Bartlesville, Okla., is now a speed control and sales engineer with the Reeves Pulley Co., Columbus, Ind. He is sales consultant on variable speed application, speed control, velocity, tension and drive control.

Seven SAE members were in attendance at the 1951 Detroit meeting of the Engineering Committee of the American Association of Motor Vehicle Administrators. Their names appear in bold face in the following list (starting at foreground corner of table and moving clockwise): W. F. Sherman, technical manager, A.M.A., Detroit, Mich.; E. F. Daniels, chief of Vehicle Inspection Bureau, Motor Vehicle Division, Trenton, N. J.; **LOUIS REZNEK**, mechanical engineer, Bureau of Motor Carriers, I.C.C., Washington, D. C.; **CAPT. W. L. GROTH**, safety engineer, Department of State Police, Richmond, Va.; Lt. D. B. Rigg, Washington State Patrol, Olympia, Wash.; J. J. Dolan, Department of Safety, Nashville, Tenn.; **W. L. CROSS, JR.**, Department of Motor Vehicles, Hartford, Conn.; George E. Keneipp, director of Vehicles and Traffic, Washington, D. C.; **C. A. CHAYNE**, chairman of A. M. A. Engineering Advisory Committee, Detroit, Mich.; **DON BLANCHARD**, secretary, SAE Technical Board, New York, N. Y.; **ALFRED W. DEVINE**, Registry of Motor Vehicles, Boston, Mass.; **DAN M. FINCH**, Department of California Highway Patrol, Berkeley, Calif.; L. S. Harris, executive director, A.A.M.V.A., Washington, D. C.; Raymond E. Grout, Motor Vehicle Department, Montpelier, Vt.; Levi R. Flint, Automobile Division, Department of State, Augusta, Maine; Kenneth F. Neu, representative, Region III, A.A.M.V.A., Des Moines, Iowa; and J. E. P. Darrell, Department of Highways, St. Paul, Minn.

GEORGE B. ALLEN, staff engineer for Chrysler Corp., retired on July 1 after 42 years in the automotive industry. He plans to take a six-month rest, beginning with a trip through the West which he and Mrs. Allen are now taking, but may take on some engineering work early next year.

Allen came to his post at Chrysler in 1946, when he was transferred from Dodge Division, where he had been staff engineer, passenger car division. He had been with Dodge since the end of World War I.

Allen served as a captain in the engineering division of the Army Ordnance Department in World War I, and aided in caterpillar tank development while stationed in this country. Ordered to France, he supervised all experimental testing in connection with the transportation of motorized field artillery. He was presented with an Army citation for efficiency for his work in France.

A graduate of the University of Illinois in mechanical engineering, Allen entered the automotive industry with Hudson Motor Car Co. He joined SAE in 1921 and is currently a member of the Passenger Car Activity Committee.

HANS LANZ, who was an instructor in engineering at Brown University, has accepted a position with the aircraft gas turbine division of General Electric Co. in Boston, Mass. Lanz will conduct theoretical investigations and design work on test equipment.

ROBERT J. WOODS, SAE vice-president in charge of aircraft activity and chief design engineer of Bell Aircraft Corp., is the author of a message saluting the aeronautical engineers and industry of France on the occasion of the 19th International Aeronautic Exhibition in Paris. The message appears in the June issue of the French aeronautical journal "L'Air" . . . "From the very beginnings of Aviation, France has been a leader marching in the vanguard of Aviation Progress," wrote Woods. "The World will never forget the names of Bleriot, Breguet, Farnam, and the score or more other French Aviation Pioneers, whose great accomplishments have contributed so much to the development of the Science and Art of Flying . . . On behalf of the Aircraft Activity of the Society of Automotive Engineers of the United States of America, I salute the magnificent job you have done, as individuals and as an industry, to recreate from the ashes of your ruins, a fine high-ranking France-in-the-Air."

JACKSON G. KUHN, formerly a research physicist for Hughes Aircraft Co., is now head of mechanical development of the new Pacific Mercury Research Center at Santa Barbara, Calif. The new company has been organized to develop equipment utilizing infra-red energy for the Armed Forces.

ROBERT T. LUKENS is test engineer for All States Engineering Co., Trenton, N. J. Lukens was previously chief test engineer for Thermoid Co., also of Trenton.

STANLEY DIAMOND is now working on hydraulics research for North American Aviation, Inc., at the plant at Inglewood, Calif. Diamond was previously associated with Visking Corp., Chicago.

CHARLES E. WILSON, defense mobilizer and president of General Motors Corp., will be the principal speaker at the closing session on Oct. 19 of the World Metallurgical Congress sponsored by the American Society for Metals in Detroit. He will speak on the strategic importance of world metal conservation and production.

ELVIN B. LIEN has been promoted to industrial sales engineer with Union Oil Co. of California, Oakland, Calif. He was formerly supervisor of lubricating oil and grease sales in San Francisco. In his new position, Lien will handle the coordination of technical information between marketing, research and manufacture.

E. M. BAUDER, formerly with A. V. Roe Canada, Ltd., is now working on planning and routing in the mechanical department of Massey-Harris Co., Ltd., Toronto, Ontario.

ANDERS G. PETTERSON is now a technical assistant in manufacturing engineering at the Dearborn Engine Plant of Ford Motor Co. Petterson was formerly a project engineer with Cross Co., Detroit.

PAUL L. HATLEBERG, formerly a wheel engineer for Goodyear Tire & Rubber Co., Akron, Ohio, is now a sales correspondent for Twin Disc Clutch Co., Racine, Wis.

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GEORGE P. FENN has been promoted to manager of the sales development division of Caterpillar Tractor Co., Peoria, Ill. Fenn, who has been with Caterpillar since 1935, was formerly assistant manager of the division.

A. HAROLD FRAUENTHAL has announced the construction of a new plant for A. Harold Frauenthal, Inc., of Muskegon, Mich. The new plant will turn out the 2200 Series Frauenthal Grinder, which Frauenthal developed during World War II. President of the company, Frauenthal will continue his duties as chairman of the board of Kaydon Engineering Corp., also of Muskegon.

WILLIAM C. FORD has been appointed manager of the quality control department of Lincoln-Mercury Division's gas turbine plant in Detroit. One of the three Ford brothers, he joined the company in 1949 and has since served in various departments, including sales and advertising and industrial relations. Ford is a director of Ford Motor Co. and since 1950 has been a member of the company's administration committee. He is also president of the Edison Institute.

OBITUARIES

BELDEN H. EATON

Belden H. Eaton, a past chairman and founder member of SAE Pittsburgh Section, died June 8 at the age of 52.

Though a native of West Pittston, Pa., Eaton's first job was in Elmira, N. Y., as floor foreman for La France Garage, Inc., in 1915. He later worked for Willys Marrow Mfg. Co. in Elmira, and in 1918 returned to Pennsylvania as shop foreman for J. R. Gordon Co., Scranton. Eaton joined the Bell Telephone Co. of Pennsylvania in 1920 as a mechanic, and a year later was promoted to motor vehicle inspector. He remained with Bell for the rest of his life, and at the time of his death was plant supervisor of motor vehicles.

Eaton was one of the earliest members of Pittsburgh Section and its chairman for 1931-32. Older members still remember the meeting during his term at which, in order to demonstrate certain points on a large Buick, Eaton and two others removed a plate glass window, turned the car on its side, and got it into the hall with less than an inch to spare. Eaton spoke to the Section on service engineering in 1933, and later, as a member of the governing board, drew up an organization chart defining the responsibilities of officers and committees.

JAMES E. ELLOR

James E. Ellor, assistant chief engineer of Rolls-Royce, Ltd., died in Middlesex Hospital, London, on July 16 after a long illness. He was 59.

Ellor had been with Rolls-Royce for 24 years. On his appointment in 1927, he was made responsible for development work on superchargers, and shortly after this a single-sided centrifugal supercharger was fitted to the Rolls-Royce Kestrel engine. He later assisted in the development of a supercharger for the Rolls-Royce "R" engine which powered the Supermarine S. 6, winner of the Schneider Trophy in 1929.

Ellor's work on superchargers for the "R" engine led to the development of a single-stage and later a two-stage supercharger for the Merlin engine. During World War II he was sent to this country as technical representative of Rolls-Royce to assist the Packard Motor Car Co. in the production of the Merlin engine.

Since the war, Ellor's specialized knowledge has been applied to the development of compressors for gas turbine engines, and he has been responsible for research work on the Derwent, Nene, and Avon engines.

In addition to being a life member of SAE, Ellor was a fellow of the Royal Aeronautical Society and a member of the Institute of Aeronautical Sciences.

FRANK G. OBERLE

Frank G. Oberle, divisional sales manager for American Bosch Corp., died suddenly at his home in Chicago on July 16.

Though only 44 years of age, Oberle had been associated with American Bosch Corp. since 1925 and had been manager of the Chicago office for six years. He had previously held similar positions in New York and Cleveland.

Oberle was a member of the Illinois Athletic Club and of the American Bosch 25-Year Club as well as of SAE.

ZBIGNIEW JOSEPH KARCZEWSKI

Zbigniew Joseph Karczewski, designer with the research department of Ford Motor Co., died April 13. He was 57.

Born in Poland, Karczewski received his degree in mechanical engineering from the Polytechnic of Lwow. He then worked as machine and motor chassis designer for a Warsaw company and for the Renault and Citroen companies in Paris. In 1941 he came to Canada, where he was employed for two years on the design of army vehicles for the Ministry of Supply. He came to this country after the end of the war, and was associated with Alpha Tool Works, Detroit, before spending a year on the design and development of a special two-cycle industrial motor for his own company. He joined Ford in 1949 as a machine designer. Karczewski is survived by his mother and brother, both in Poland.

AVON BROWN

Avon Brown, project engineer for Hall-Scott Motor Division of ACF-Brill Motors Co., died in an auto accident in Oakland, Calif., on June 26. He was 37. At the time of the accident Brown was alone in his car, which apparently failed to take a sharp turn in the road.

A native of Los Angeles, Brown studied mechanical engineering at the University of California at Los Angeles and at Berkeley. He then worked as a draftsman for Ray Oil Burner Co. and later Enterprise Engine Co., both of San Francisco. He joined Hall-Scott Division in 1940 as a draftsman, and was appointed project engineer in 1946.

Brown is survived by his wife and two daughters.

JOHN E. GRINER

John E. Griner, 26, died July 29 at Clementon, N. J. At the time of his death he was serving in the Army and was stationed at Frankford Arsenal, Philadelphia, Pa.

Griner was born in South Bend, Ind. He graduated from Purdue University in October, 1945, with a degree in mechanical engineering. From the time of his graduation until he entered the Army last January, Griner was a field engineer in the research department of Caterpillar Tractor Co., Peoria, Ill.

While living in Peoria Griner served on the governing board of SAE Central Illinois Section.

IRVING R. RUBY

Irving R. Ruby, president of Ruby Chevrolet, Inc., Chicago, died May 19 at the age of 54. A resident of Winnetka, Ill., Ruby was stricken with a heart attack while playing golf and died shortly thereafter in the Edgewater Hospital. He is survived by his wife and three children.

CHARLES E. FOGG

Charles E. Fogg, 65, died unexpectedly at his home in Havertown, Pa., on June 20.

A graduate of the Williamson Trade School of Media, Pa., Fogg joined the Autocar Co. of Ardmore, Pa., in 1910 as a tool designer. In 1918 he moved to the Rodenhausen Body Works in Philadelphia. Shortly afterwards Fogg went into business for himself in housing construction, but returned to Autocar in 1933. He was chassis development engineer for that company at the time of his death.

STUDENTS ENTER INDUSTRY

GORDON C. BATEMAN (Indiana Technical College '51) is in training in tool designing with Saginaw Steering Gear Division of General Motors Corp., Saginaw, Mich.

PAUL H. KRAMER (University of Minnesota '51) is now with Standard Oil Co. (Ohio), Cleveland.

DONALD F. VANICA (Tri-State College '51) is a product design engineer for Ohmer Corp., Rockwell Mfg. Co., Bellefontaine, Ohio.

JEAN C. DuBUISSON (University of Colorado '51) is a design engineer at the U. S. Naval Shipyard, San Francisco.

ROBERT HOIT TRAEGER (University of Washington '51) is a test engineer for General Electric Co., Schenectady, N. Y.

ROBERT K. CRAIG (University of Colorado '51) is working in the gas turbine unit of Boeing Airplane Co., Seattle, Wash.

PAUL PETRELLA (Newark College of Engineering '51) is a junior laboratory engineer with Hyatt Bearings Division of General Motors Corp., Harrison, N. J.

ROBERT E. BOWEN (General Motors Institute '51) is at the Saginaw transmission division of GMC Chevrolet Motors Division, Saginaw, Mich.

ROGER D. OSBORNE (University of Oklahoma '51) is a stress analyst with Chrysler Corp., Detroit, Mich.

ARNOLD O. OLCOTT (University of Wisconsin '51) is in the U. S. Army at Camp Breckinridge, Ky.

CHARLES J. CARNEY (Catholic University of America '51) is in the design section of Goodyear Aircraft Co., Akron, Ohio.

ROBERT J. KNOTT (Washington State College '51) is working at the Puget Sound Naval Shipyard, Bremerton, Wash.

RALPH JUCHCINSKI (University of Illinois '51) is with Ka-Mo Tools, Inc., Cicero, Ill.

STEPHEN M. BLAZEK (Carnegie Institue of Technology '51) is with the Navy Department's Bureau of Ships, Washington, D. C.

HOWARD C. WHEELER (California Polytechnic College '51) is a mechanical engineer at the U. S. Naval Ordnance Test Station, Pasadena, Calif.

DEAN W. WARD (Bradley University '51) is with Liberty Mutual Insurance Co., Boston, Mass., as a safety engineer.

G. E. JAMES BLAIKLOCK (University of Toronto '51) is a field engineer for Foundation Co. of Canada, Montreal, P. Q., Canada.

DONALD W. SCHAEFER (University of Colorado '51) is a marine engineer at U. S. Naval Shipyard, San Francisco, Calif.

JAMES F. COVINGTON (University of Washington '51) is now an ensign aboard the U. S. S. Floyds Bay.

DANIEL STERN (New York University '51) is with the Navy Department's Bureau of Ships, Washington, D. C.

LAWRENCE N. GERING (General Motors Institute '51) is a time study engineer with Burroughs Adding Machine Co., Detroit, Mich.

E. BONAR LINDSAY (McGill University '51) is assistant superintendent of maintenance for Molson's Brewery, Ltd., of Montreal, Que., Canada.

ROBERT M. BAILEY (Pennsylvania State College '51) is with the Pennsylvania Railroad Co., Philadelphia, Pa.

S. ELI CERISE (University of Colorado '51) is in Long Beach, Calif., with Douglas Aircraft Co.

ERROL D. RODDA (University of Illinois '51) is in training with Caterpillar Tractor Co., Peoria, Ill.

VICTOR E. SWENSON (University of Illinois '51) is at the John Deere Waterloo Tractor Works, Waterloo, Iowa.

MARTIN FRANK FINFROCK (Purdue University '51) is in Bartlesville, Okla., with Cities Service Oil Co., subsidiary of Cities Service Co.

DEAN C. McGAHEY (Pennsylvania State College '51) is employed in the Beacon laboratories of Texas Co., Beacon, N. Y.

WARREN DEAN KING (Tri-State College '51) is now with North American Aircraft, Inc., Los Angeles, Calif.

RALPH E. LAMBRECHT (Purdue University '51) is a project engineer for Johnson Motor Co., Waukegan, Ill.

RALPH E. SCHUMANN (Ohio State University '51) is with Cummins Engine Co., Columbus, Ind., as an engineering trainee.

EDMUND W. SHUSTER (Pennsylvania State College '51) is purchasing agent and expeditor for E. W. Bliss Co., Salem, Ohio.

EDWIN E. ELMGREN (Indiana Technical College '51) is now with Webster Mfg. Co., Inc., Tiffin, Ohio.

JOHN DAVID VAGNETTI (Lawrence Institute of Technology '51) is now with Burroughs Adding Machine Co., Detroit, Mich.

FRANKLIN S. FREDERICK (Bucknell University '51) is with Consumers Research, Inc., Washington, N. J.

SANFORD LUSTIG (New York University '51) is doing testing for the Air Materiel Command at Wright-Patterson Air Force Base, Dayton, Ohio.

RICHARD W. STRAW (Indiana Technical College '51) is with Bendix Aviation Corp., South Bend, Ind., as a development engineer.

FREDERICK J. CLEMENS (Aeronautical University '51) is with the Columbus division of North American Aviation, Inc., Columbus, Ohio.

ROBERT C. MEYER (Bradley University '51) is in training with the service department of Caterpillar Tractor Co., Peoria, Ill.

WILLARD L. BURDEN (Washington State College '51) is now a designer at Moffett Field, Calif.

MARVIN O. BURDEN (Washington State College '51) is a 2nd lieutenant in the Air Force Reserve.

DONALD D. WEIDHUNER (University of Illinois '51) is at Wright-Patterson Air Force Base, Dayton, Ohio, as a powerplant engineer at Wright Air Development Center.

ALLEN S. ROSE (University of Wisconsin '51) is a junior engineer for Chance Vought Aircraft Division of United Aircraft Corp., Grand Prairie, Texas.

EDWIN J. KOJSZA (University of Pittsburgh '51) is a pneumatic engineering trainee with Westinghouse Air Brake Co., Wilmerding, Pa.

RODERICK E. WHEELER (Bradley University '51) is now a test engineer with Douglas Aircraft Co., Inc., Long Beach, Calif.

EUGENE A. HUGO (Aeronautical University '51) is a draftsman for North American Aircraft Co., Los Angeles, Calif.

CHARLES S. ELDER, JR. (University of Colorado '51) is now employed by Bell Aircraft Corp. in Buffalo, N. Y.

JOSEPH P. BERLEY (Missouri School of Mines '51) is in St. Louis, Mo., with McDonnell Aircraft Corp.

COLIN F. ROBERTSON (Yale University '51) is an officer in the U. S. Marine Corps Reserve at Quantico, Va.

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Committee E-25 takes time out from discusions of the new six-digit AS's and other standards for engine and propeller utility parts to pose for Wright Aeronautical Corp.'s photographer at the committee's June 11 meeting. Seated are (left to right) W. B. Billingham, R. F. Schwarzwalder, M. L. Stoner, Chairman J. D. Clark, G. N. Cole and G. M. Garcina. Standing are (left to right) R. L. Wadland, R. E. Weymouth, C. C. Hurlburt, H. W. Epler, D. L. Kidd, Capt. R. C. Rethmel, Gustaf Carvelli, D. H. Secord, and A. S. Hanson

Society Publishes First Six-Digit AS's

FIRST three in the six-digit series of SAE Aeronautical Standards have just been issued. They are:

"AS100016 thru AS100025 Lockwire, Brass"

"AS100026 thru AS100035 Lockwire, Cres Steel"

"AS123751 thru AS123850 Cotterpin —Corrosion Resistant"

These are issued on vellum transparent enough so that a purchaser may reproduce them by blueprint or similar processes for reproducing drawings. More six-digit AS's are in preparation.

Like the six-digit AN and MS standards the six-digit AS standards cover utility standard parts for the aircraft engine industry and they do call out part numbers. The six-digit AS numbers will not be duplicated in the AN-MS numbering system. The AS system is "nonsignificant"—that is, the individual digits do not refer to dimensions or other features of the part the number identifies.

Six-digit AS's are standards that were prepared by Committee E-25, Engine and Propeller Standard Utility Parts; approved by the SAE Aeronautics Committee and SAE Technical Board and by the Engine Technical Committee of the Aircraft Industries Association; submitted through AIA to the military services; and considered but not adopted by the services for publication as AN or MS standards. The military services decided not to adopt the three standards just published as AS's for reasons of logistics.

More than 225 SAE-prepared standards have been adopted as AN's or MS's; only a few prepared for that purpose have not been adopted. But SAE has opened the six-digit AS series at the request of AIA to take care of the rare cases where industry needs the standard and the services do not. The services are cognizant of the new AS series and have no objection to offer to it.

Chairman of Committee E-25, Engine and Propeller Standard Utility Parts, the committee responsible for AS's in the six-digit series, is J. D. Clark.

Flight Test Methods For Helicopters Studied

FLIGHT test methods for helicopters are now being standardized by SAE Aircraft Committee S-2.

Heretofore, the flight test methods used by helicopter manufacturers have been those for fixed-wing aircraft modified as necessary to obtain the information required to pass civil and military qualification tests.

The new report attempts to assimilate all present knowledge of the subject. It sets forth what at this time is generally regarded as an adequate outline of test procedures applicable to both military and commercial helicopters.

The report covers:

1. Instrumentation.
2. Air-speed calibration.
3. Performance.
4. Flying qualities.
5. Powerplant tests.
6. Structural airworthiness.
7. Vibration.

R. A. Young, Navy Bureau of Aeronautics, is chairman of the subcommittee that did the actual work. Other members are: John Mazur, Ralph Lightfoot, Leon Crane, and Tom Harriman.

At present a draft of the report is being circulated to the members of the S-2 Committee for approval or comment. It is hoped that the report will be approved and ready to be issued in the near future.

Revised Standard for Piston Rings and Grooves

THE revised SAE Standard for Piston Rings and Grooves and Recommended Practice on Piston and Ring Nomenclature (see August, 1951 SAE Journal, page 85) is now available as an SAE Special Publication (SP-80). The Standard was approved in June, 1951, and will appear in the 1952 SAE Handbook.

Multilithographed copies may be obtained from the Society of Automotive Engineers, 29 West 39th Street, New York 18, N. Y. Single copies are priced at 50¢ each to SAE members and $1.00 each to nonmembers. Quantity prices are as follows:

3-24 copies — each 50¢
25-49 copies — each 40¢
50 or more — each 30¢

Panel Starts Work on ARP For Auto-Pilot Installation

INITIATION of a program to develop an Aeronautical Recommended Practice for automatic-pilot installation marked the first meeting of a newly formed A-4, Aircraft Instruments Committee panel. This ARP is to provide industry with a guide to automatic-pilot installation in aircraft and will suplement existing specifications covering the instrument itself.

The group decided to begin the project by determining (1) performance standards which should be expected from an ideal installation, and (2) general aircraft limitations which could

F. S. Bonney, United Airlines, Chairman of the newly formed A-4, Aircraft Instruments Committee panel which is to develop an ARP for automatic pilot installation

directly or indirectly affect any phase of automatic-pilot performance.

Serving on the panel with Chairman F. S. Bonney, United Airlines, are K. Hobein, Bendix Aviation; O. B. Lolmaugh, Douglas Aircraft; O. E. Patton, Civil Aeronautics Administration; C. Russell, Republic Aviation; L. N. Swisher, Sperry Gyroscope; and W. W. West, American Airlines. Committee A-4 is in the Aircraft Accessories and Equipment Division.

Div. XX OK's Principle For Shot Life Testers

DIVISION XX is recommending that principles of the M-C shot life testing machine be used for shot-acceptance testing on a trial basis until December 7, 1952. At that time, the Division intends to review the recommendation.

Division XX is the shot peening division of the SAE Iron and Steel Technical Committee.

Various shot-test machines were considered at Division XX meetings. Discussion brought out that the M-C machine weighs 105 lb, operates automatically, and requires only 50 g of shot for its sample. The M-C machine was developed by R. L. Mattson of GM Research and D. A. Cargill of Precision Shot Co. They have agreed to supply prints of the machine without royalties to those wishing to build it.

Fig. 1 shows the M-C machine. It consists of a triangular rotor, A, and the stator, B, both of which are mounted so as to permit rotation about a common axis. The rotor is driven by a suitable motor, usually ¾ hp at a speed of 7600 ± 100 rpm. The stator is likewise driven by any suitable means at approximately 100 rpm in the same direction. The test chamber is completed by the addition of side plates, C, which rotate with the stator. A suitable seal, D, is needed where the rotor shaft enters the test chamber. To permit the opening of the chamber for introducing and removing the shot sample, the stator-side plate assembly is usually split along the line XX. The section to the right can then be readily removed, usually by undoing a pair of screw fastenings, and replaced as desired.

The machine is used to subject the shot particles to repeated impact in a manner similar to that in production shot peening and blast cleaning machines. The resulting failure of shot particles is said to be similar in nature.

The procedure outlined by the machine's originators calls for a 50-g sample to be run for a predetermined period of time, then removed and screened on a sieve. The shot remaining on the sieve is weighed and the weight compared with that of an established reference material.

The time of running must be determined for each general type of shot and for each size. Mattson reports that average life corresponds quite well with the life at the point where 55% of the particles are broken. By testing a sample to progressively longer periods, a time can be established when 55% of the initial weight of the sample passes through the selected sieve. This period he suggests as the running time.

For the sieve, Mattson suggests that a size be selected which corresponds to the maximum size of particles being discarded from the particular production machines for which the shot is intended.

Division XX plans to discuss this procedure during its next meeting, September 19, 20, and 21 at The Homestead, Hot Springs, Va.

9 New Steels Proposed For Cold-Forming Wires

COMPOSITIONS for nine alternate alloy steels proposed for cold heading and cold forging wires were published late in July by the American Iron and Steel Institute, after consultation with the SAE Iron and Steel Technical Committee.

Of the nine compositions, five are for component sizes up to ½ in. in diameter, inclusive. The steels are:

40B37 Modified
8035
TS8135
14B35
5035

The remaining four compositions are for component sizes over ½ to ¾ in., inclusive, in diameter. They are:

40B37 (for aircraft applications)
80B37
TS8137
50B37

The nine alternate alloy steels are proposed to conserve critical alloying elements. The variety of grades "is intended to provide the degree of flexibility necessary to meet the manufacturing economies in the production of a wide range of cold headed and cold forged components made from alloy steel wire," according to the AISI. These steels are expected to help bolt manufacturers, especially.

The two Tentative Standard steels contain 0.70-0.90% manganese. All the others call for 0.70-1.00% manganese.

The complete compositions are published on one sheet titled "Proposed Alloy Steels for Cold Heading and Cold Forging Wires, July 1951" to be added to the AISI Steel Products Manual Section 28—Alloy Steel Wire. Copies of the sheet are available from American Iron and Steel Institute, 350 Fifth Avenue, New York 1, N. Y.

CIMTC Group Inspects Labs at Fort Belvoir, Va.

MEMBERS of the Steering Committee of the Construction and Industrial Machinery Technical Committee were recently afforded an excellent opportunity to inspect the U. S. Army Corps of Engineers' Research and Development Laboratories at Fort Belvoir, Va.

A welcome to Fort Belvoir and to the

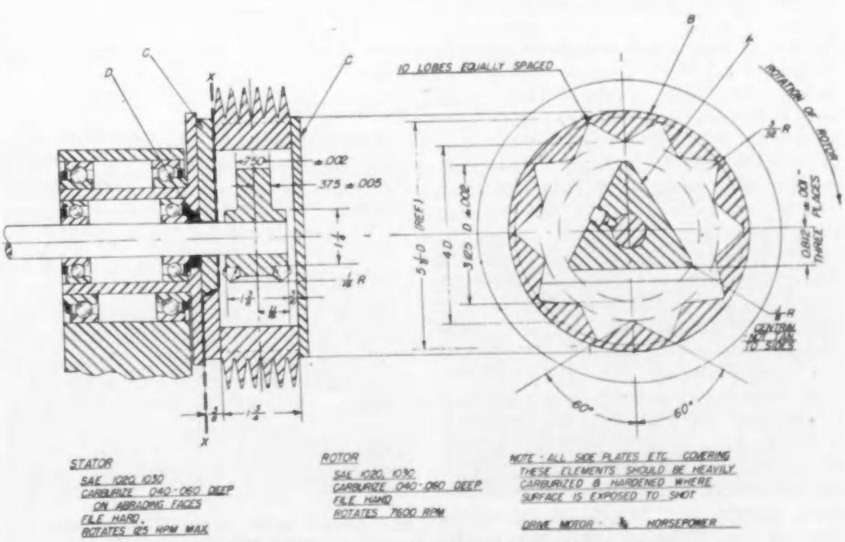


Fig. 1—Essential dimensions of M-C shot fatigue testing apparatus

facilities of the ERDL by Commanding Officer O. B. Beasley opened the May 22 meeting of this group. Discussion involved the possible preparation under CIMTC sponsorship of a test code, perhaps in the form of a manual, for testing earthmoving equipment used by the Corps of Engineers.

As a result of interest expressed by Engineer Corps personnel, the CIMTC agreed that a study should be made of oil filters with respect to interchangeability, types, sizes, functioning, and so forth. It was held that eventual standardization of the oil filter element should be tied in with any oil filter test code that is developed.

Col. D. J. Hammond, Chief of the Research and Development Division, Office of Chief Engineer, Washington, spoke on the progress being made in the standardization of bore sizes, pistons, pins, rings, bearings, rods, and so forth. The results of this work were seen later in the day in the engine test laboratory.

Other subjects in which the Corps of Engineers staff expressed unusual interest were standby heaters and flotation.

Laboratory Tour

A tour of the laboratories showed the excellent equipment available for engine testing. Five different engine sizes have been developed here through the cooperation of Chrysler, Ford, General Motors, Cummins, International Harvester, Hercules, Buda, and Waukesha—all of whom are building engines to the five standard sizes.

Packaging techniques, protective materials, and moisture-proof papers used in the Packaging Laboratory proved particularly interesting to industry members of CIMTC. The group observed demonstrations of test machinery covering shock, vibration, falling, tumbling, crashing, and compression.

One of the most complete test laboratories at Fort Belvoir contains a large cold room, a small cold room, and a tropical laboratory. The large cold room will take a vehicle 23 ft long, 14 ft wide and 13 ft high. Temperatures can be controlled from +165 F to −85 F and held at −65 F with an engine running at full load. The humidity range is from 20% to 100% and simulated altitudes from sea level to 35,000 ft. The tropical fungus room will hold temperatures at 95 F and humidity at 97% and will grow South Sea Island fungus.

Nine hundred acres are set aside as a proving ground for earthmoving equipment.

The CIMTC members observed a number of special demonstrations and were shown the latest in approved lighting for scrapers and other dirt handling equipment which makes working around the clock easy.

CALENDAR

NATIONAL MEETINGS

MEETING	DATE	HOTEL
1951		
TRACTOR and PRODUCTION FORUM	Sept. 10-13	Schroeder, Milwaukee
AERONAUTIC, AIRCRAFT PRODUCTION FORUM, and AIRCRAFT ENGINEERING DISPLAY	Oct. 3-6	Biltmore, Los Angeles
TRANSPORTATION	Oct. 29-31	Knickerbocker, Chicago
DIESEL ENGINE	Oct. 29-30	Drake, Chicago
FUELS and LUBRICANTS	Oct. 31-Nov. 1	Drake, Chicago
1952		
ANNUAL	Jan. 14-18	Book-Cadillac, Detroit
PASSENGER CAR, BODY, and MATERIALS	March 4-6	Book-Cadillac, Detroit
AERONAUTIC, AIRCRAFT ENGINEERING DISPLAY, and TECHNICAL AIR REVIEW	April 21-24	Statler, New York City
SUMMER	June 1-6	Ambassador and Ritz-Carlton, Atlantic City, N. J.
WEST COAST	Aug. 11-13	Fairmont, San Francisco
TRACTOR	Sept. 9-11	Schroeder, Milwaukee

SECTION MEETINGS

Buffalo—Sept. 27

Hotel Sheraton dinner 7:00 p.m. Meeting 8:00 p.m. The N. Y. State Truway illustrated with sound movie. Speaker to be announced—engineer, N. Y. State Highway Department.

Cincinnati—Sept. 24

Engineering Society Headquarters, dinner 6:30 p.m. Meeting 8:00 p.m. Tools for Transportation, Paul Gillan chief engineer, White Motor Co. Refreshments after the meeting.

Indiana—Sept. 13

Hotel Marott, Indianapolis, dinner 7:00 p.m. Meeting 8:00 p.m. Social Half-Hour 6:30 p.m. Power Steering in 1951, W. K. Creson, vice-president of engineering, Ross Gear & Tool Co.

Kansas City—Sept. 10

Rosselli's, 912 Walnut, dinner 6:30 p.m. Meeting 8:00 p.m. The Engineering Approach to Service, Carl T. Doman, national service manager, Ford Motor Co. Refreshments will be available before dinner.

Mid-Michigan—Sept. 18

Owosso Country Club, dinner 7:00 p.m. Meeting 8:15 p.m. Automotive Cooling, Ralph Holmers, chief engineer, Harrison Radiator Division, GMC. Golf in the afternoon.

Twin City—Sept. 10

Hotel Normandy, Minneapolis, dinner 6:30 p.m. Meeting 8:00 p.m. The Engineer and Public Relations, S. L. Stolte, consulting engineer.

SAE Section Meetings

dance in the palatial Main Club House. Among the winners of the dancing contest staged by Chairman Millicent Hatch were Mrs. J. Edward Schipper, Jr., and Mrs. John A. C. Warner.

Chairman of the Outing and Dinner-Dance was Merrill C. Horine; William E. Conway was vice-chairman. Miss Judy McCormick was the gracious reception chairman, and W. R. "Bob" Cubbins put on one of his amazing "greeter's acts" to the astonishment of all.

Section Treats Ladies To Punch, Chicken, Movies

• Spokane-Intermountain Section
C. W. Shields, Field Editor

June 28—Spokane-Intermountain Section played host to 36 on their annual Ladies Night. The bowl of fruit punch had to be refilled three times before the members and guests sat down to a dinner of chicken fried in butter.

After the dinner, Chairman Peter Favre presented Louis P. Johnson with his past chairman's certificate, and Donald Majer, program chairman, conducted the drawing for door prizes.

Favre introduced the new officers of the Section, and asked their wives' permission for one night out a month to guarantee their presence at SAE meetings, which was enthusiastically granted. Favre then showed movies of his trip last fall through France, Italy, and Switzerland.

Met Section Enjoys Outing, Dinner-Dance

• Metropolitan Section
Leslie Peat

June 29—More than 120 Metropolitan Section members, their wives and guests attended the first Outing and Dinner-Dance staged by the group in ten years at the Sleepy Hollow Country Club at Scarboro-on-Hudson.

Despite rain in the morning and a heavy mist during most of the afternoon, most of the planned events were held. Golf prizes were won by Chairman Dorothy Larson and Mrs. B. H. Lowers in the women's event, and Clayton Farris won the men's championship with J. L. Carson the runner-up. First in Flight A was E. R. Smoley, while L. M. Stringham won Flight B. William E. Conway and C. E. Davis were runners-up. E. L. Carroll was men's golf chairman.

The swimming events, which turned out to be more of a frolic than a serious aquatic contest, were arranged by S. G. Tilden, Jr. Winners of the five events were William R. Cubbins, Jr., Louis F. Moody, Jerry Geigle, Mrs. Nancy Cornwall and Mrs. Mary Geigle.

Mrs. Mel Hogan and Bridge Chairman Grace Horine won at canasta and bridge. Soft ball and trapshooting drew no comers, but Henry Jennings and Herbert Happersberg were on hand just in case. The tennis match arranged by Walter Peper was cancelled by rain, but several joined chairman A. T. Gregory in horseback riding.

Eighty-five attended the dinner-

Gas Misers, Wasters Highlight Annual Outing

• New England Section
C. G. MacDermot, Field Editor

June 19—The annual New England Section outing held at the Marlboro Country Club, Marlboro, Mass., attracted the largest attendance to date, with over 200 members and guests present. Glenn Whitham, who selected

Continued on Page 104

Among those attending the Dinner-Dance of Metropolitan Section were (left to right) S. G. Tilden, Outing Chairman M. C. Horine, Mrs. John A. C. Warner, Mrs. Grace Horine and SAE Secretary and General Manager John A. C. Warner, who greeted the members and guests in a brief talk following dinner

The Gas Miser Contest at New England Section's outing recorded a difference of 8 mpg for different drivers over the same course. Left to right: Edward G. Moody, Glenn S. Whitham, winning gas miser, and C. G. MacDermot

Perfect weather gave an extra gleam to the old and new cars displayed in the automotive exhibition arranged by Harry Stanton at the annual outing of New England Section at Marlboro Country Club

Silver and Gold Cards for Long-Time Members

THE SOCIETY OF
AUTOMOTIVE ENGINEERS, Inc.
29 WEST THIRTY-NINTH STREET • NEW YORK

E. W. UPHAM

is a Silver Card member of SAE, having completed more than 25 years of active membership.

MEMBERSHIP CARD
Valid to
September 30th, 1952

B. B. Bachman
TREASURER

THE SOCIETY OF
AUTOMOTIVE ENGINEERS, Inc.
29 WEST THIRTY-NINTH STREET • NEW YORK

S. H. WOODS

is a Gold Card member of SAE, having completed more than 35 years of active membership.

MEMBERSHIP CARD
Valid to
September 30th, 1952

B. B. Bachman
TREASURER

LONG-TIME MEMBERS OF THE SOCIETY are receiving special membership cards this year. Those who have been active members for more than 25 years will receive Silver Cards and those whose memberships have extended more than 35 years will receive Gold Cards with their dues bills, beginning this year. In the future, Silver and Gold Cards will go each year with dues bills to members as they complete 25 and 35 years of dues payment. This method of recognizing long-time members was proposed by the Membership Committee and voted by the Council during the 1951 SAE Summer Meeting.

How Many Do *You* Know?

For 35 years or longer, 263 men (not including life members) have been members of SAE. About 40% of them are under 65 years of age. They represent a fairly average cross-section of the whole SAE membership in everything except age. It includes vice-presidents of engineering and research workers, presidents and equipment salesmen, design engineers and patent attorneys . . . and almost every other professional category is represented in the SAE Roster.

Every letter in the alphabet except "Q," "U," "X," and "Z" is accounted for in the list of surnames and every section of the country has natives in the group.

Here are the men who will be the first to get the new SAE Gold Membership Card this fall.

Allen, Gould
Anderson, D. E.
Anderson, John A.
Anibal, Benjamin H.
Ash, Charles S.

Bagley, Herbert P.
Balough, Charles
Baninger, John H.
Barter, Percy L.
Batt, W. L.
Baumgartner, Walter J.
Beach, Edward W.
Begg, Russell S.
Bender, Frank M.
Bevin, Sydney
Bill, Harry L.
Billings, Cecil M.
Boedecker, Kenneth J.
Booth, Frederick E.
Booth, James S.
Borg, George W.
Borland, Bruce
Borton, Clement A.
Bower, F. A.
Breitenbach, Julius M.
Briggs, Walter O.
Brown, Sanford
Brush, A. P.
Bryan, A. C.
Bull, Arthur A.
Burkhardt, Fred C.
Burt, Clayton R.
Bush, Charles T.

Caldwell, Frank W.
Carlson, G. W.
Carlton, Lee C.
Case, George S.
Champ, Norman B.
Champney, Ralph P.
Chandler, Milton E.
Charavay, Frederick
Chase, Herbert
Chase, Julian
Chase, T. P.
Chesnutt, Ralph C.
Chilton, Roland
Chryst, William A.
Clayden, A. Ludlow
Cook, Willis D.
Cox, Claude E.
Creager, F. L.
Crockett, Charles H.
Cummings, Lloyd A.
Curello, John J.

Dalton, Hubert K.
Daniels, Robert W.
Davis, Francis W.
Deeds, Edward A.
DeTurk, L. M.
Dick, Burns
Dick, Robert I.
Dickey, H. L.
Dorris, G. P.
Duryea, J. Frank
Du Val, Eugene C.

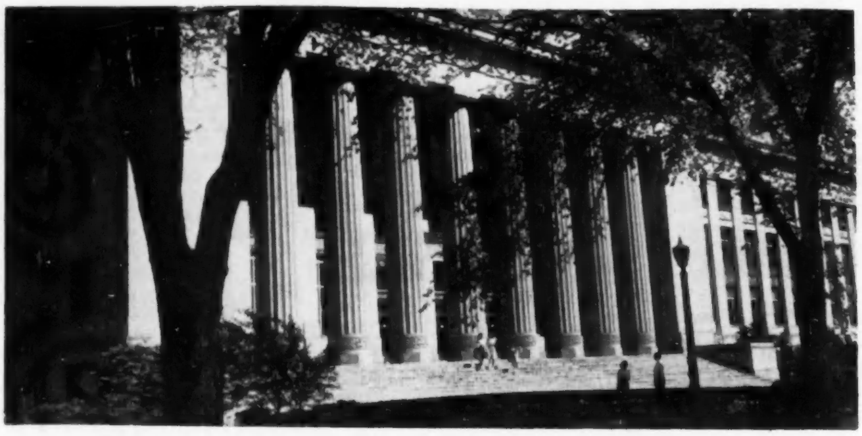
Eason, Clarence M.
Eells, Paul W.
Elliott, Ernest A.
Evans, Gordon M.
Evans, Harold W.
Evans, Leigh R.

Fageol, Frank R.
Farkas, E. J.
Favary, Ethelbert
Fielder, Reuben E.
Fisher, James B.
Fisher, W. L.
Frehse, Albert W.
Fried, Jerome A.
Friedgen, Arthur E.
Froelich, Oscar E. H.
Froesch, Charles
Fuller, George F.
Fulton, Arthur O.

Gallimore, Keith F.
Gamble, D. Edwin
Gelzer, Jennings A.
Gemmer, G. A.
Gilchrist, C. F.
Gilligan, Frank P.
Gleason, Don Thomas
Gleason, James E.
Greenlee, James T.
Guernsey, Charles O.
Gunn, E. G.

Halbleib, Edward A.
Hall, Frederick P., Jr.
Hallett, George E. A.
Harper, Harvey W.
Haskell, Allan G.
Hawxhurst, Major B.
Heldt, P. M.
Hendrickson, Robert T.
Herreshoff, A. G.
Herreshoff, Charles F.
Herrmann, Karl L.
Hewitt, Edward R.
Hewlett, Van Wyck, Jr.
Hicks, Harlie H.
Hoffman, Roscoe C.
Holley, George M.
Horine, M. C.
Howard, Frank A.
Hughes, Frederick G.
Hunt, Ormand E.

Illmer, Louis
Jacobsen, Charles H.
Jardine, Frank
Jencick, Stephen
Jennings, William F.
Jinnette, Charles W.
Kalb, Lewis P.
Kalish, David F.
Karey, R.
Kelly, Moore
Kelsey, C. W.
Kemble, Thomas S.
Kerr, Harry H.
Kilborn, Karl B.
King, Charles B.
Kishline, Floyd F.
Klocke, W. H.
Kloepper, V. C.
Knowles, R. W.
Kreidler, D. W.
Kuenzel, S. H. Hunter
Laddon, I. Machlin
Landis, Mark H.
Lane, Abbott A.
Lane, Ralph S.
Libby, Albion D. T.
Liebowitz, Benjamin
Litchfield, Paul W.
Little, William C.
Loening, Grover C.
Lucke, Charles E.
Lyman, Albert A.
Mabley, Carlton Ray
MacCoull, Neil
Mackenzie, Kenneth G.
MacPherson, Earle S.
Martin, Glenn L.
Maurer, Leroy F.
McCain, George L.
McKinley, Charles W.
McLaughlin, R. S.
McMullen, George C.
Meiser, George H.
Michel, C. A.
Milbrath, Arthur F.
Miller, Albert R.
Miller, Clarence W.
Moncrieff, V. I.
Moorhouse, Alfred
Moskovics, Frederick E.
Mott, Charles S.
Mummert, Arden J.
Murray, C. E.
Myers, James L.
Nash, Evan R.
Nead, John Hunter
Nelson, Adolph L.
Nelson, Nelson B.
Northrup, H. Murray
Oldfield, Lee W.
Olsen, Thorsten Y.
Oppe, Charles
Ozias, Glenn M.
Page, S. H.
Palmer, Austin P.
Parker, Edward L.
Parker, Orrel A.
Pearce, John W. B.
Pierce, Harold S.
Pierce, Hugh M.
Plimpton, R. E.
Polson, Joseph A.
Poole, Alfred J.
Purdy, Raymond J.
Read, Balfour
Reeves, Alfred
Ricker, Chester S.
Riordan, John M.
Rippingille, E. V.
Robertson, Edwin A.
Rockwell, Willard F.
Roesch, Daniel
Rosenthal, William C.
Ross, E. B.
Round, George A.
Russel, R. F.
Scarratt, Albert W.
Schaal, Earl V.
Schipper, J. Edward
Schmid, Martin H.
Schoenrock, Otto R.
Schonitzer, R. J.
Schramm, Adolf P. C.
Schultheis, Everett M.
Schwitzer, Louis
Scott, Carl F.
Sheahan, Thomas W.
Shepard, E. H.
Sintz, Claude
Slack, Frederick W.
Slauson, Harold W.
Sloan, Alfred P., Jr.
Slonneger, J. C.
Smith, Horatio W.
Smith, Lon R.
Snow, Herbert C.
Sowers, D. W.
Sparrow, Stanwood W.
Spencer, Henry K.
Stahl, Rodolphe
Stevens, Clarence C.
Stewart, Arthur L.
Stoddard, H. G.
Stone, Porter E.
Stratford, Charles W.
Strickland, S. A.
Swenson, Carl E.
Tarantous, Harry A.
Taub, Alex
Tector, D. C.
Thomas, T. R.
Tone, Fred I.
Vaughan, Guy W.
Veal, C. B.
Wahlberg, N. Erik
Walter, Maurice
Watson, John W.
Watson, P. A.
Watson, Richard A.
Weaver, E. W.
Whitbeck, J. V.
Whitham, Glenn S.
Whitworth, Stanley
Wiggers, John
Wilson, C. E.
Wilson, O. P.
Winans, E. W.
Wingquist, Sven G.
Wood, Clarence G.
Wood, Garfield A.
Wood, John G.
Woodall, Herbert J.
Woods, S. H.
Woollard, Frank G.
Worthington, Wayne H.
Yeomans, Lucien I.
Young, Otto William
Youngren, Harold T.



SAE at

Angell Hall, best known building on the campus of the University of Michigan

In 1853, long before the advent of the "horseless carriage," the University of Michigan appointed its first professor of engineering. Alexander Winchell, who received the appointment of Professor of Physics and Civil Engineering, served in that position until 1855. He later served as a professor of geology, zoology, and botany. From this general beginning the field of engineering gradually grew, adding department after department as each specialty attained prominence, until in 1895 the University's Board of Regents established the College of Engineering. But it was not until some 18 years later, in 1913, that the University offered its first automotive laboratory course.

One of the members of this two-hour course was Walter E. Lay, a student member of SAE. His close association with students following his appointment in 1915 as a full-time teaching assistant laid the groundwork for the later establishment of the SAE student group. Through his continuing interest in the activities of the organization, the University received a charter in 1938 which officially established a Student Branch of the SAE. Lay, now a professor of mechanical engineering, ran his first automotive tests on a 1910 four-cylinder Krit and a 1908 four-cylinder Franklin. Recognized as a pioneer in automotive engine testing, body streamlining and riding comfort research, Lay has spent many hours during informal coffee sessions discussing the intricacies of the gasoline engine that has had such a tremendous effect upon the development of the United States.

From the beginning of the Student Branch in 1938 until 1945, Lay was faculty adviser to the group. Following him, Paul Metzler, now of the Pontiac Division of General Motors Corp., served as faculty adviser until 1948.

At the present time the chapter's faculty adviser is Jay A. Bolt, professor of mechanical engineering, who also acted as vice-chairman of the student activity of the Detroit Section of SAE during 1950.

SAE Student Branch members gain first-hand knowledge of the new 180-hp V-8 Chrysler engine. Left to right: Professor Jay A. Bolt, faculty adviser; Peter Haas, secretary-treasurer; and Harold Thom, vice-chairman

With the fortunate location of the University of Michigan close to the heart of the automobile industry, SAE Student Branch members have an opportunity to gain first-hand knowledge and acquaintance with the developments, operations, and personnel in many of the nearby plants. Sponsored trips to various divisions of General Motors Corp., Ford Motor Co., Chrysler Corp., and other automotive plants, as well as to the plants of related industries such as the Ethyl Corp., are common events throughout the school year for chapter members.

The chapter also enjoys the cooperation of automotive industries in obtaining excellent speakers for campus SAE meetings, which are scheduled for the benefit of all engineering students. One such notable session during the past spring was a lecture on the new 180-hp V-8 Chrysler engine presented by Harold Welch of the Chrysler Engineering Department.

According to national enrollment figures, the University of Michigan SAE student group ranks fourth largest among the Big Ten schools. Including its present 57 members, a total of about four hundred students has participated in the activities of the chapter since its inception on the campus in 1938. In addition, 20 members of the University's teaching and research staff are presently associated with SAE, many of them active partici-

the University of Michigan

pants in meetings and on committees of the Society. Although there are 12 technical and 7 honorary societies in the University of Michigan's College of Engineering, the Student Branch of SAE is considered one of the most active organizations operating among the 2000-strong student body of the College.

Over 600 SAE Members Attended The University of Michigan. Among them are:

Ernest J. Abbott (1918-25), Ralph G. Abbott (1926-30), Arthur A. Abel (1903-07), Paul C. Ackerman (1918-22), A. Stuart Adams (1919-23), Daniel M. Adams (1940-41), R. L. Adams (1935-38, 1938-39), D. E. Ahrens (1922-28), Clare A. Aldrich (1948-49), Edwin L. Allen (1916-17, 1919), Lawrence B. Alliason (1910-13), Darrel D. Alton (1912-16).

Harold E. Andersen (1922-26), A. F. L. Anderson (1921-25), William D. Angst (1938-42), Charles W. Anklam (1923-27), Maxwell N. Anning (1942-46), Wallace F. Ardussi (1923-31), W. G. Armor (1936-40), Anderson Ashburn (1936-40), Walter G. Auer (1923-27), Charles F. Austerberry (1945-47), Harold W. Austrow (1948-50), Morris G. Avery (1940-41), L. F. Ayres (1938-40).

C. F. Bachle (1923-27), Elbridge F. Bacon (1922), E. L. Bailey (1946-49), Harold W. Bailey (1925-29), Stuart G. Baits (1910-14, 1915), Lee R. Baker (1929-31), Thomas L. Baker (1925-29), S. L. Balasubramanyam (1948-50), Milton S. Bald (1917-22), L. M. Ball (1925-29), Philip Barkan (1946-48).

Nevin C. Barnes (1912-18), Arthur S. Bassette (1927-35), John N. Bauman (1921-22), Robert Baxley (1934-39), Clarence H. Beach (1908-12), T. F. Beaman (1924-28), R. R. Beardsley (1915-20), Jay C. Beaumont (1906-10), F. N. Beauvais (1937-41), J. S. Beechler (1928-32).

Carlos R. Bell (1940-44), Jay Cee Bell (1937-39, 1945-47), Carl M. Berry (1920-25), Cleafe Allen Best (1945-49), E. C. Billings (1908-12), William J. Bird (1927-33), Roger Birdsell (1913-17), Emerson B. Blair (1938-41), John J. Blessley (1945-49), D. G. Blocher (1921-26).

Leonard Boddy (1920-27), Smith Bolton (1920-24), L. C. Bootes (1903-06), Joseph A. Boothroyd, Jr. (1947-49), Robert Bothfeld (1946-47), F. H.

Continued on Page 98

Students leave campus in front of the West Engineering Building after classes via Dennison Arch

SAE Members Who Attended The University of Michigan—Continued

Bourke (1912-15), David D. Bowe (1935-40), Lloyd L. Bower (1912-16), James G. B. Bowles (1903-07), Donald S. Bowman (1946-50), Donald A. Boyd (1927-32).

C. A. Brady (1923-26), Donald F. Branstrom (1946-49), H. R. Breniser (1929-33), David A. Brennan (1940-48), Richard D. Brewer (1929-36), Robert S. Bridge (1914-17), Robert O. Brines (1938-42), Glenn H. Brink (1926-28), Laurence E. Burgess (1921-C. O. Broders (1936-40), E. B. Brown (1923-28), Ray H. Brundige (1929-34),

L. Ray Buckendale (1912-16), Robert D. Buick (1922-27), Charles F. Bunker (1926-28), Laurence E. Burgess (1921-24), Hubert D. Burnside (1916-18), W. T. Burwell (1922-26), H. L. Byerlay (1930-34).

Donald M. Campbell (1914-20), James D. Campbell (1940-48), Malcolm C. Campbell (1915-17), M. H. Campbell (1933-38), Ronald W. Campbell (1947-49), Robert L. Camping (1932-37), Robert L. Candlish (1938-41), Alden B. Carder (1937-39), Jerry E. Cardillo (1941-44), Joseph S. Cardillo (1934-39), Don A. Cargill (1941-43), Horst Miller Carioba (1948-49).

Darl F. Caris (1921-25), Clarence G. Carlson (1940-48), Edward G. Carlson (1940-42), R. E. Carlson (1908-12), E. L. Carroll (1911-15), Alexander E. Carson (1917-24), Beecher B. Cary (1926-30), John P. Casserly (1932-34), Harold Chalk (1925-29), James M. Chandler (1944-50), James F. Chapman (1921-26), Jack E. Charipar (1942-43, 1943-47).

Seymour J. Cheney (1927-30), Harry E. Chesebrough (1930-32), A. F. Christian (1921-26), George T. Christiansen (1937-41), Nicholas P. Christy (1947), Bruce E. Clark (1933-38), Richard B. Clark (1926-30), Samuel Kelly Clark (1943-46, 1947-48, 1948-50), B. J. Cleaver (1912-17), Allen E. Cleveland (1931-35), Edwin L. Cline (1929-30).

William E. Cobey, Jr. (1934-39), John Gardner Coffin, Jr. (1944-48), Thomas D. Colbridge (1937-42), John W. Collins, Jr. (1935-39), George H. Compter (1935-38), Joseph Conn (1933-34), Howard W. Crusey (1937-39), Lloyd Anderson Cummings (1907-12), Frederick T. Cushing (1934-38).

Norman C. Damon (1919-22), Louis J. Danis (1933-39), A. H. d'Arcambal (1908-12), E. H. Davidson (1915-16), Stuart E. Davidson (1927-32), Raymond J. Dean (1939-43), Oscar G. DeClerck (1936-40), Fred J. Delvitt (1925-30), Inder M. Dewan (1946-48), Carl T. Doman (1920-22).

Glidden S. Doman (1938-42), Douglas Dow (1918-22), Harcourt C. Drake (1912-16), Vincent M. Drost (1930-33), Ralph H. DuBois (1935-40), W. M. Duckwitz (1926-31), W. M. Dudley (1933-34).

Archie H. Easton (1932-35), Robert H. Eaton (1945-49, 1950), Emil E. Ebner (1922-25), Nathaniel Ely (1921-25), Francis H. Emerson (1927-32), Charles E. Ervin, Jr. (1938-40), L. A. Estes (1904-10), E. B. Etchells (1928-32), Eldred E. Evans (1927-32), George D. Evans (1929-33).

Everett G. Fahlman (1914-18), John E. Fahlman (1946-50), Richard H. Fashbaugh (1942-43, 1946-49, 1949-50), Harry W. Faust (1925-29), Daniel Wolf Feldman (1942-43, 1946-49), Irving I. Feldman (1926-33), James R. Ferguson (1905-09), Charles L. Fike (1935-36), Lyman C. Fisher (1927-34), Clarence T. Fishleigh (1913-17).

C. W. Floss (1915-19), Charles L. Foreman (1908-13), Donald A. Forman (1944-45, 1946-47), Jack R. Forsyth (1946-48), Charles W. Frederick (1919-23), Aaron Friedman (1939-43 1946-47), Stanford J. Friedman (1947-49), Walter F. Friend (1909-13), Arthur H. Fries (1928-31), Ned Fuller, Jr. (1934-39), Frank W. Furry (1933-38).

A. D. Gardner (1922), Mark Garlick, Jr. (1925-28), F. R. Gaylord (1937-39), J. C. Geniesse (1915-24), D. Gerdan (1927-32), Warren Gilbert (1919-22), William R. Gillette (1938-39), Henry J. Gilmartin (1927-31), David R. Glass (1944-46).

Richard Goldsmith (1915-17), Charles W. Good (1914-18), John F. Gordon (1922-23), H. W. Gouldthorpe (1923-27), Joseph J. Gouza (1942-44), Robert Warren Graham (1942-49), W. H. Graves (1915-19), Louis G. Gray (1923-25), Frederick L. Green (1920-26).

B. S. Grewal (1928-31), Richard F. Grogan (1935-39), Mark D. Gross (1947-50), Wilson T. Groves (1938-42), Jerry M. Gruitch (1929-33), F. C. Gustafson (1932-36), Edward H. Gustafson (1938-40).

Edgar A. Hahn (1920-26), Emil H. Hahn (1943-46), E. E. Haight (1933-39), Clarence A. Hall (1939-41), R. T. Hall (1938-42), Peter Hugh Haller (1939-42), Robert C. Hamilton (1937-42), Douglas W. Hamm (1935-39), Dean B. Hammond (1927-31), William C. Hanway, Jr. (1930-34), William Harms (1949-51).

G. R. Harrington (1916-21), Gordon W. Harry (1919-23), H. B. Haskins (1914-18), Charles N. Haskins (1933-37), Reeve R. Hastings (1934-36), John G. Haviland (1934-37, 1938-39), L. S. Haynes, Jr. (1939-42), Ronald M. Hazen (1919-22), Charles N. Heinen (1938-42).

Louis F. Held (1937-42), Curtis J.

SAE Members Who Attended The University of Michigan—Continued

Hendricks (1938-41), Robert J. Hefferon (1949-50), Walter B. Herndon (1929-30), Harold Walter Herring (1929-33), Alvin J. Herzig (1922-31), D. M. Hesling (1936-37), Robert V. Hessler (1917-19), Lewis R. Hetzler (1937-41).

Harold A. Hicks (1912-17), Alan L. Higbie (1932-36), Frank H. Highley (1930-34), Eugene E. Hildebrandt (1943-47), Carlton Hill (1913-17), E. K. Hill (1913-17), Robert A. Hitch (1939-41), Kirke K. Hoagg (1909-13), Harold D. Hoekstra (1927-29), Evert C. Hokanson (1927-29).

Robert D. Holbrook (1943-44, 1946-47), A. W. Hollar, Jr. (1936-41), John R. Hollowell (1943-44), Dan W. Holmes (1927-31), Stanley R. Hood (1949), C. G. Hoover (1909-13), Harold S. Howe (1936-39), Russell T. Howe (1921-25), Richard M. Howlett (1937-39, 1946).

Ralph A. Hoxie (1937-38), J. A. Hubbard (1922-24), W. H. Hubner (1922-23), Edward A. Hulbert (1918-22), L. Gaylord Hulbert (1913-17), Charles K. Hunt (1925-34), John H. Hunt (1901-05), O. E. Hunt (1903-07), W. B. Hurley (1906-11), S. B. Ingerson (1933-34).

Richard D. Jacobs, II (1941-44), A. P. Jambulingam (1948), Frank M. Jobes (1923-27), A. F. Johnson (1924-28), Edward T. Johnson (1927-29), Carl V. Johnson (1911-15), Ernest R. Johnson (1917-22), Glenn A. Johnson (1937-41), W. E. Jominy (1911-16), Ben F. Jones (1936-40).

Carl F. Joseph (1913-17), Carl W. Kalchthaler (1924-25), Robert J. Kasurin (1940-44), Sheldon Kavieff (1941-44, 1946-47), Daniel P. Kearney (1919-22), Hugh E. Keeler (1907-13, 1931), Carlos D. Kelly (1923-28), William C. Kelly (1945-47), A. L. Kimball (1907-11).

John Edward King (1941-43), Robert W. King (1936-40), Howard F. Kirk, Jr. (1937-40), Jack Edward Kline (1936-37), J. Charles Klotz (1929-33), Daniel O. Klute (1939-42), W. H. Knapp (1935-40), F. D. Knoblock (1922-27), Robert F. Kohr (1913-17), Thomas David Kosier (1943-44).

George A. Kozloff (1940-43, 1946-47), Nelson J. Kreider (1937-41), Alvin M. Kurz (1949-50), Charles W. Kynoch (1908-12), Uolevi L. Lahti (1942-47), George G. Lamb (1923-28), Walter R. Laster (1945-46), Walter Edwin Lay (1910-15), Robert C. Leary (1942-43, 1946-47), W. T. Leeper (1919-20).

Frederic A. Leisen (1925), Simpson C. Leonard (1917-20), Philip W. Lett, Jr. (1947-50), Daniel M. LeVine (1928-31), J. A. Lignian (1925-28), Carl A. Lindblom (1929-31), John D. Lindsay (1930-34), Donald R. Long (1946-47), John R. Long (1937-41), Anthony Lopucki (1942).

John P. Lord (1938-41), William F. Lowe (1919-24), H. W. Luetkemeyer (1926-31), Kenneth V. Lundquist (1924-27, 1929-30), Tao-Wen Ma (1945-46), E. Stephen Madaras (1939-41), Roger Mahey (1934-39), Thomas P. Mainzinger (1946-47), Witold Malecki (1931-34), Clarence R. Mallon (1946-49), Ward P. Mann (1945-49).

H. S. Manwaring (1911-16), E. D. Marande (1933-40), D. T. Marks (1937-41), E. S. Marks (1910-14) Duane E. Marquis, Marvin R. Marsh (1946-47), L. S. Martz (1915-22), George W. Mason (1909-13), James M. Mason, Jr. (1934-41), Wendel E. Mason (1916-21).

Frederick C. Matthaei, Jr. (1943-47), William L. Mattheessen (1949-50), E. R. Maurer (1905-09), W. A. Maynard (1918), Edward John Mazurkiewicz (1943-46), Dale B. McCormick (1932-36), Harold J. McCotter (1923-28), James McCracken (1936-40), N. Heath McDowell (1930-33), Charles S. McKenzie (1936-38), John F. McLean, Jr. (1934-39), Orin W. McMullan (1918-22).

Donald H. McPherson (1943-48), John G. McQuaid (1934-38), Joseph F. Meade (1913-17), William O. Meckley (1937-40), W. R. Meese (1917-21), Milton Menkus (1946-47), Edgar W. Meranda (1916-19), Ralph H. Mertz, Jr. (1944, 1946-49), Orest A. Meykar (1925-30), George Miakinin (1944-47).

Foster H. Middleton (1943-44, 1946-47), F. L. Miller (1926-29), George F. Miller, Jr. (1938-40), Harry E. Miller, Jr. (1940-47), J. Musser Miller (1917-21), R. Wendell Miller (1923-25), Sidney E. Miller (1926-30), William L. Miron (1944-47), Herbert L. Misch (1939-41), Harold F. Mitchell (1918-23).

George J. Monfort (1909-13), Charles D. Moore (1941-44), Neil A. Moore (1916-22), Charles H. Morris (1935-36), Hudson T. Morton (1919-24), E. L. Mosshamer (1934-36), Arthur B. Mugg (1947-48), Morris J. Muzzy (1920-24), George S. Myers (1932-33, 1936-37), W. H. Naegely (1915-20).

Charles Arthur Nagler (1934-38), J. H. Nead (1905-09), Roy S. Neff (1945-48), C. E. Nelson (1929), Edward J. Nesbitt (1942-43), Frank R. Nethaway (1913-18), Gene T. Neudeck (1937-41), Harley M. Newcomb (1931-35), Francis J. Newton (1931-33), John B. Nicolls, Jr. (1934-40).

Paul T. Nims (1933-39), Walter Noffke (1939-43, 1945-46), Raymond John Novotny (1947-48), L. C. Nyman (1930-34), John T. Olsen (1936-37, 1939-41), L. E. O'Neil (1938), A. William Orr, Jr. (1932-36), J. H. Otis (1913-17), Sacid M. Ozker (1941-42).

Continued on Page 100

SAE Members Who Attended the University of Michigan—Continued

J. A. Packard (**1919-24**), Anthony J. Pane (**1937-42**), John R. Parker (**1935-39**), Clyde R. Paton (**1919-23**), Roy W. Paton (**1920-25**), Donald A. Paull (**1938-40**), Gerald Robert Pearsall (**1946-49**), Russell H. Peebles (**1941**), Charles T. Perkins (**1911-17**), Frank W. Person, Jr. (**1933-37**). Frederick John Peterson (**1946-50**), Willard R. Phillips (**1939-42**), Hugh M. Pierce (**1906-10**), William G. Pierce (**1933-36**), Edward K. Pilcher (**1919-23**), William D. Pittsley (**1942-46**), Fletcher N. Platt (**1934-38**), Bryant Walker Pocock (**1932-34**), R. W. Pollard (**1909-12**), H. G. Portman, Jr. (**1930-32**), Elbert L. Potter (**1921-24**).

William Cedric Potter (**1941-43, 1945-47**), Edward N. Potthoff (**1917-21, 1923-26**), Nathaniel S. Prime (**1935-36**), D. C. Prince (**1908-10**), George W. Pusack (**1938-42**), James Leslie Quinnelly (**1946-48**), J. D. Redding (**1928-31**), B. G. Reed (**1928-32**), Howard A. Reed (**1921-24**), Harold William Reese (**1949-50**).

J. McGill Rayner (**1927-28, 1933-34**), L. A. Rice (**1935-36**), Dale L. Richardson (**1929-32**), R. L. Rickett (**1923-32**), Richard Lewis Riedel (**1939-41 1942-43, 1946-47**), Frank O. Riley (**1929-33**), Earl F. Riopelle (**1941-45**), John D. Roach, Jr. (**1940-48**), William H. Robbins (**1944-49**), David Turner Roberts (**1946-50**), George W. Roberts (**1940-44, 1946**).

T. M. Robie (**1910-14**), Joseph I. Robinson (**1934-39**), R. W. Rockefeller (**1927-32**), Max M. Roensch (**1925-26**), Robert S. Root (**1933-37**), I. T. Rosenlund (**1935-37**), Tunis C. Ross, Jr. (**1932-36**), Durward E. Rossman (**1924-28**), E. S. Rowland (**1930-33**), Thurman O. Ruettinger (**1936-39**), Basil J. Ryder (**1923-28**).

A. J. St. George (**1928-29**), Richard C. St. John (**1948-49**), William E. Sala (**1944-46**), Maxwell E. Salisbury (**1917-21**), Lowell F. Sarnes (**1930-35**), Bennett S. Savin, Jr. (**1935-38**), David J. Schaffer (**1939-41**), N. H. Schermer (**1916-20**), John F. Schmidt (**1931-35**), Richard Schneidewind (**1921-23**).

W. H. Schomburg (**1910-14**), Walton H. Schub (**1927-31**), A. B. Schultz (**1925-27**), Arthur J. Schuneman (**1946-49**), Robert W. Scoville (**1927-31**), Edmund C. Sedlack (**1929-33**), Herbert M. Seeger (**1926-30**), Cecil R. Sessions (**1940-43**), Frederic W. Sevin (**1913-17**).

Glenn C. Shaffer (**1930-36**), Robert J. Shaltis (**1941-44**), W. A. Shayer (**1911-16**), Thomas W. Sheahan (**1914-17**), J. H. Sheets (**1934-37**), Bruce M. Sheffer (**1937-42**), W. J. Sherrin (**1934-39**), Ricklef W. Shirk (**1938-42**), Charles D. Simmons (**1946-50**), Walter H. Simpson (**1921**).

Newton Skillman, Jr. (**1943-47**), Ralph L. Skinner, Jr. (**1946-50**), Donald G. Smellie (**1914-17**), D. W. Smith, Jr. (**1926-30**), Francis L. Smith, Jr. (**1948-49**), H. R. Smith, Jr. (**1930-34**), Hamilton W. Smith (**1927-31**), Harold W. Smith (**1919-20**), Lewis F. Smith (**1931-41**), Robert W. Smith (**1934-39**).

William R. Smith (**1943-46**), William C. Smothers (**1938-41**), Rufus C. Snook (**1939-41, 1946-48**), Norman N. Snyder (**1938-42**), Munjandira A.

SAE Members Who Attended the University of Michigan—Continued

Somaya (1947-49), George Sonnemann (1944-49), C. P. Spiesz (1930-35), Ford W. Spikerman (1930-32), S. J. Spleet (1931-36).

Gale A. Sprague (1914-17), Elmer H. Spring (1935-39), Edward A. Stalker (1915-19), A. E. Stanyar (1939-43), Henry D. Stecher (1911-16), H. Richard Steding, III (1936-40), R. N. Steere, Jr. (1932-37), John P. Stefan (1925-27), William K. Steinhagen (1940-43, 1946-48), Harold M. Stephen (1914-18), Wesley A. Steyer (1935-39).

Robert H. Stimpson (1940-44), Seth H. Stoner (1933-34), John N. Straky (1937-38, 1943, 1945), Harold A. Strickland, Jr. (1937), Russell S. Strickland (1934-39), Kenith G. Strunk (1922-27), C. E. Stryker (1916), M. J. Taup (1931-33), Kendall D. Taylor (1940-44), Paul B. Taylor (1913-17).

Ray P. Teele (1921-22, 1926-27), Baboo Ram Teree (1927-31), Earl C. Thayer (1944), M. J. Thompson (1923-28), Louis Thoms (1916), R. F. Thomson (1934-41), T. R. Thoren (1929-32), Robert H. Thorner (1936-40), Robert K. Tiedeman (1936-40), David V. Tinder (1947-49).

Roderick G. Tipping (1947-50), Ward C. Tollzien (1923-27), Millard H. Toncray (1911-15), David F. Toot (1924-26), F. D. Townsend (1929-34), Leonard Troy (1940-41), Robert D. Truckle (1947-48), Willard I. Truettner (1924-30), George A. Tuttle (1947-49).

Stanley B. Tuttle (1932-33), Ralph Underdahl (1941), E. W. Upham (1909-13), R. G. Urch (1908-12), Everett C. Vallin (1934-40), Harry J. VanAuken (1911-12), R. E. VanDeventer (1929-31), C. H. VanHartesveldt (1932-35), Walter VanVoorhees (1938-43), Vaino J. Vehko (1936-40).

John F. Verkerke (1943), Glenn E. Vescelus (1934-36), Earl E. Wagner (1917-21), Karl F. Walker (1913-17), Francis L. Wallace (1934-36), Lyle A. Walsh (1923-26), Karl A. Walter (1932-33), Harold L. Walters (1943-47), Don J. Wangelin (1934-39), E. W. Wasielewski (1931-35), George B. Watkins (1915-21).

Gilbert Way (1924-26), Baxter Webb (1934-36), George H. Webb (1938-42), John A. Webber (1926-28), Philip S. Webster (1925-33), Nathan Weingarden (1921-24), F. Rankin Weisgerber (1917-21), David C. Weiss (1950-51), Edward F. Weiss (1935-38), Walter L. Weiss (1929-34).

Marshall Werth (1922-23, 1924-25), Edward West (1947-49), B. W. Westcott (1916-20), Frank A. Westenkirchner (1948-49), Pierce A. Weyl (1916-20), C. M. Whelan (1907-13), Wallace E. Whitmer (1945-46), Harry H. Whittingham (1913-17), Max R. Wiard (1925-29), T. H. Wickenden (1911-13).

Edward Wickland (1928-31), John C. Widman (1926-30), Grant S. Wilcox, Jr. (1928-33), Alfred O. Williams (1910-14), Howard J. Williams (1936-40), Wilfred Williams (1934-36), G. D. Wilson (1924-33), Frederick D. Wilson (1938-40), Paul I. Wilterdink (1949), Robert Lauren Wiltse (1943-47).

Robert W. Wolfe (1935-39), Robert J. Woods (1923-28), Norman L. Wuerz (1939-41), J. M. Yantis (1935-39), William H. Yenni (1929-32), Robert L. Yung (1943-45, 1946-47, 1948-49), Fred M. Zeder (1905-09), James C. Zeder (1918-22), Thomas E. Zeerip (1938-42), Kenneth M. Zemke (1940-44, 1946-47), R. E. Zimmerman, Jr. (1936-40), John Zytkewick (1938-42, 1944-45).

25 Years Ago

Facts and Opinions from SAE Journal of September, 1926

In his paper on "How I Fly at Night between New York and Cleveland," Air Mail pilot Wesley L. Smith said: "When forced to land on an emergency field on account of bad weather at the next terminal field, we do not stop the engines in winter. . . . Engines are very hard to start when cold, and the caretaker of an emergency field is not enough assistance. When an engine is stopped in winter, it is usually necessary to send two mechanics to the pilot's assistance to get it started again."

■

The September issue of the SAE Handbook will be the second issue of the Handbook in bound form.

■

Following the activities of the American Engineering Standards Committee in recent years, the advisability of organizing a special body to supervise or participate in the formulating of engineering standards for adoption in various countries has been discussed. . . . A conference of interested SAE members will be held at its headquarters in New York City on Sept. 8. . . . One member, objecting to part of the proposed constitution for the new organization, has written: "I wonder whom you are going to pick as the man to do the fighting in connection with what is the proper standard for an American article used in Europe."

■

The Navy is rapidly obtaining a line of three aircooled engines that will meet most of its requirements. The large aircooled engines are now equipped with 2 to 1 reduction gears, and can be installed geared or with direct drive in twin-engined patrol airplanes. Thus the Navy then has the entire range of its aircraft aircooled.—Com. E. E. Wilson, USN, in paper "Aircooled Engines in Naval Aircraft."

■

One conclusion by F. C. Mock in a paper on "Spring Suspension and Riding Qualities" was: "Under present limitations of passenger car design, every effort should be made to locate the weight over the axles rather than between them."

Recommendation by R. L. Skinner in conclusion of paper, "Oil Rectifiers and Crankcase Oil Dilution": "Build all new internal combustion engines with suitable equipment for the positive prevention of dilution. It will then be possible to maintain the viscosity, pour-test and flash-point of a crankcase oil over a greatly increased period. Not only will this result in lengthening the engine life, but it will also assist in conserving an irreplaceable natural resource."

■

Advocates of aircooled engines are now prepared to take the offensive in the debate as to the relative merits of this type and the water-cooled engine for aeronautic work. This was made evident at an Aeronautic Meeting session on Sept. 2.

■

The Tractor Meeting will be held in cooperation with the American Society of Agricultural Engineers at the Hotel Sherman in Chicago, Dec. 1 and 2.

■

FORTY-ONE of the companies advertising in the September, 1926, SAE Journal are among SAE Journal's advertisers thus far in 1951. Here's the list (using 1951 names): Aetna Ball & Roller Bearing Co.; American Felt Co.; Associated Spring Corp.; Bethlehem Steel Co.; Bohn Aluminum & Brass Corp.; Borg & Beck Division, Borg-Warner Corp.; Clark Equipment Co.; Continental Motors Corp.; Dole Vale Co.; Electric Auto-Lite Co.; Fafnir Bearing Co.; Federal Mogul Corp.; Firestone Tire & Rubber Co.; Fuller Mfg. Co.; Goodyear Tire & Rubber Co.; Harrison Radiator Division, GMC; Hyatt Bearings Division, GMC; International Nickel Co.; Leece-Neville Co.; Lipe Rollway Corp.; Long Mfg. Division, Borg-Warner Corp.; Marlin-Rockwell Corp.; Mechanics Universal Joint Division, Borg-Warner Corp.; Morse Chain Co.; Muskegon Piston Ring Co.; New Departure Division, GMC; Ross Gear & Tool Co.; Shore Instrument & Mfg. Co.; SKF Industries, Inc.; Spicer Mfg. Division, Dana Corp.; Stewart-Warner Corp.; Timken Roller Bearing Co.; Titeflex, Inc.; U.S. Rubber Co.; U.S. Steel Corp.; Vanadium Corp. of America; Waukesha Motor Co.; Wisconsin Motor Corp.; Wyman-Gordon Co.; Young Radiator Co.; Link-Belt Co.

Section News

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the date, proved an excellent weather forecaster, and the first golfers teed off shortly after nine in the morning.

For those interested in automotive styling and design, a complete automotive show was arranged by Harry Stanton of the "Boston Globe." A Chrysler "Firepower V-8" hard-top convertible equipped with Hydraguide hydraulic steering and torque converter was furnished by C. E. Fay Co. of Boston. F. W. Davis of Waltham brought his 1951 Cadillac with hydraulic steering, a pilot model in this respect. Dealers in all makes of American and foreign cars cooperated in furnishing display models, and in addition to the 1951 passenger cars diesel tractors by International, Mack, Autocar and General Motors, a Dodge gasoline tractor, and a White tilting cab job were shown.

Several members drove their prize veteran autos to the outing, to the delight of antique lovers. Bob Townsend brought his 1921 Mercer, and Frank Gardner drove up in a Ford Model "A" Phaeton as trim and shiny as the day it left Dearborn in 1928. Also on display were a Locomobile, a Buick, two Ford Model "T's", and F. Bannister's distinctive modified Ford roadster and two other racing cars, all three equipped with Ford engines reworked by Hanson Engineering Co. of Lexington. Frank Johnson drove George Waterman's 1908 Mercedes racer to the Club. The Mercedes was one of three cars built for the German team competing for the Grand Prix at Brooklanes, England, in 1909, and averaged 108 mph in that race. It was one of the entries in the first Indianapolis Speedway race in 1922.

A safety demonstrator truck supplied by the K. D. Mfg. Co. was equipped with signal circuits and safety lighting devices recently recommended by SAE for general use on automotive equipment.

Highlight of the outing was a gasoline mileage contest modelled on the recent Grand Canyon Economy Runs. Contestants competed either in saving gas in the "balloonfoot" contest or wasting it for the "leadfoot" honors. A 1951 Ford with conventional transmission supplied by Newton Motor Sales Co. was equipped with an Electro Products gasoline flow meter calibrated to 1/100 gal. Twenty-two members piloted the car around the five-mile course, each accompanied by an official observer who disqualified drivers not obeying the rules. Free wheeling and turning off the engine were not allowed, and enforcement of the rules was strict: the committee reserved the right to require contestants caught tampering with the engine "to buy a

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Section News

Continued

drink for everyone at the bar at the time of the violation."

Glenn Whitham of Charles Street Garage and Elty Guiou of New England Telephone Co. tied for first place as gas misers with a high of 19.8 mpg. A high score of 21.6 mpg was recorded, but the driver who obtained this remarkable economy was disqualified. Honors in the throttle jockey contest were won by H. B. Hawk of Freedom Valvoline Oil Co., for a low of 11.4 mpg. Harry Stanton headed the committee that arranged the event.

After an excellent steak dinner, tickets were drawn for 165 door prizes ranging from pocket flashlights to table radios, and prizes were awarded for the various contests.

The names of the members of the governing board were announced, and the members of Dave Webber's Outing Committee and the many others who contributed to the success of the outing were warmly thanked. Thirteen past chairmen of the Section were present, and guests from other Sections were Dwight Hannay, Bob Gardner, and Hollister Moore of the New York office.

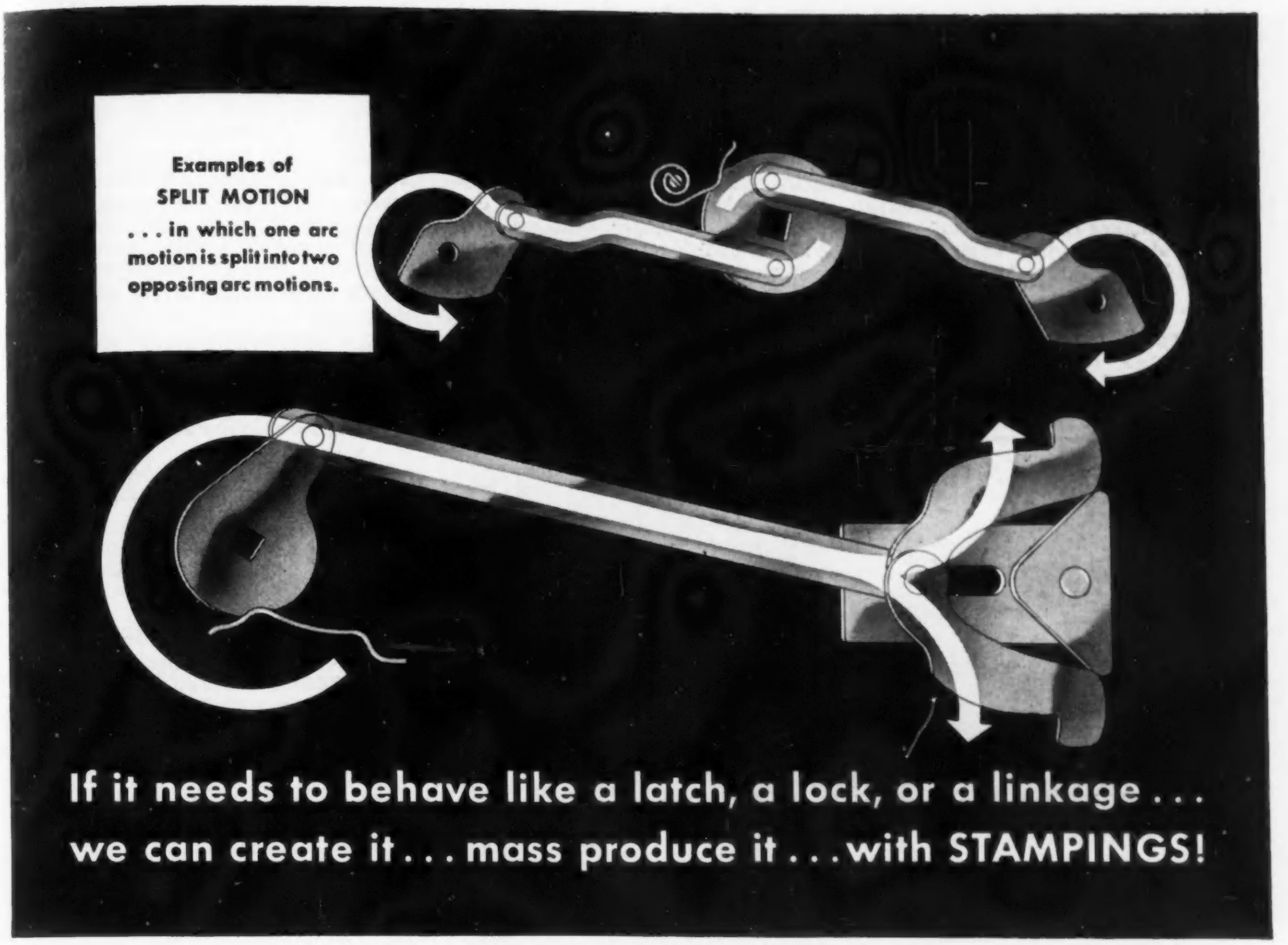
Walter Beech Honored By University of Wichita

• Wichita Section

On July 15 the University of Wichita dedicated its wind tunnel to Walter H. Beech, founder and first president of Beech Aircraft Co. who died last November 29. According to Virgil Hackett, chairman of the SAE Wichita Section, the idea of a memorial to Beech at the University of Wichita was first suggested by William Day at a meeting of the governing board of the Section last fall.

Beech's company was among the original contributors to the fund for the wind tunnel, which was built in 1948. It is powered by a 1000 hp Allison engine with a four-bladed variable-pitch propeller which forces wind through a 7×10 ft aperture into the megaphone-shaped tunnel. The wind tunnel has been used for research by the government and local aircraft companies as well as by the University's School of Engineering.

Dwane L. Wallace, president of Cessna Aircraft Co., spoke at the brief dedication ceremony, and President Harry F. Corbin of the University of Wichita unveiled a bronze plaque on the entrance to the wind tunnel.



Our specialty is designing and producing sure-acting mechanical devices that initiate a force or motion, transmit it, control it or check it.

Furthermore, through the development of modern manufacturing techniques, we can build precision motion-devices *by stamping* . . . assemble them by welding or riveting . . . to keep the cost unusually low.

If the type of motion used in your product has formerly required "machining-accuracy", our mass-production stamping and assembly techniques may make big cost reductions possible. Our new booklet, "We Make Motions", explains our facilities further. We'll be glad to send you a copy upon request.

THE REID DIVISION OF *The Standard Products Co.*

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WE MAKE MOTIONS

Personals

Continued from Page 87

J. RONALD ROSS, who was associated with Studebaker Corp. in South Bend, Ind., is now a project engineer with Ionia Mfg. Co., Ionia, Mich.

FRANK M. KITTREDGE is now a junior test engineer for Thompson Products, Inc., of Cleveland. He was formerly with Oliver Corp., Charles City, Iowa.

GEORGE L. APPLEYARD, who has been employed in Clearwater, Fla., for the last few years, is now with Hub Motor Co., Boston, Mass., as insurance appraiser. Appleyard utilizes his hobby of photography in his work to document his estimate of damages due to fire and collisions. He has been vice-chairman of SAE New England section.

ROBERT SHERMAN is now test engineer for Wright Aeronautical Corp., Wood-Ridge, N. J. He was formerly with Fairchild Engine & Airplane Corp. in Oak Ridge, Tenn.

GEORGE C. PRILL is now a flight operations specialist with the air carrier division of the Bureau of Safety Regulation, Civil Aeronautics Board, in Washington. He was previously associated with the International Air Transport Association, Montreal, Canada.

CAPT. GEORGE W. DORR, who is stationed at Wright-Patterson Air Force Base, is now with the Air Research and Development Command. He was formerly acting chief of the reciprocating engine branch, Air Materiel Command, at Wright-Patterson Base.

ROBERT C. JUVINALL, formerly associate professor of mechanical engineering at Illinois Institute of Technology, has accepted a position with Ransburg Electro-Coating Corp., Indianapolis, Ind.

H. D. MacDONALD is now technical and wholesale representative of Fred Deeley, Ltd., Vancouver, B. C., Canada. MacDonald was previously in charge of motor transport for the Royal Canadian Mounted Police.

M. F. SPERRY, formerly manager of Highway Trailer Co., is now eastern regional manager of Reo Motors, Inc., of Lansing, Mich. Prior to 1940, Sperry was associated with Reo for 13 years as New England manager.

BYRON A. FAY, director and vice-president in charge of manufacturing of Electric Auto-Lite Co., has been elected vice-chairman of the board. In this post he joins **D. H. KELLY**, also a director, vice-president, and vice-chairman of the board.

COL. JESSE G. VINCENT has been award a certificate for outstanding service in standardization by the American Standards Association. Vincent, who recently retired as vice-president of the Packard Motor Car Co., is a past-president of SAE.

JOHN D. ROGERS, JR., formerly with California Research Corp., is now senior engineer with E. I. duPont de Nemours & Co., Inc., Wilmington, Del. He is working on the improvement of fuel and lubricating oil qualities by chemical additives.

GEORGE C. McMULLEN has retired as vice-president of Tyson Bearing Corp., Massillon, Ohio. McMullen has been an active member of SAE since 1908. He will continue to reside at his home at 1004 Yale Avenue, N.E., Massillon, Ohio.

C. W. LINDGREN is the author of "Automotive and Construction Equipment," a study in the economical use of automotive and construction equipment as it relates to management, capacity and investment.

Personals

Continued

ARTHUR C. GILBERT is now senior stress analyst in the flutter and vibration group, Republic Aviation Corp., Farmingdale, N. Y. He was previously chief vibration engineer with T. R. Finn Co.

JAMES G. DUFFY, JR., formerly with Fairchild Engine & Airplane Corp. in Oak Ridge, Tenn., is now with the atomic energy division of H. K. Ferguson Co. in New York City.

KURT GOLDMANN who also was with Fairchild in Oak Ridge, is now associated with Carrier Corp., Syracuse, N. Y.

H. W. MARSH is now senior design engineer with ABF Division, Hubb Corp., Detroit. For the past 10 years Marsh has been associated with Consolidated Vultee Aircraft Corp. in various capacities.

J. S. MUNRO has been named assistant general manager of Canadian Raybestos Co., Ltd., of Peterborough, Ontario. Munro has been with Canadian Raybestos for 10 years, most recently as chief engineer and equipment sales manager.

JAMES D. MOONEY, chairman of the board, Technical Managers, Inc., has been named general chairman of the United Hospital Fund's 1951 campaign in New York City.

THURMAN F. NAYLOR has been promoted to manager of contracting department of Metal Products Division, Koppers Co., Inc. Naylor joined Koppers in 1942, but left a year later to serve in the U. S. Air Force; since returning to the company in 1945 he has held various positions, most recently contract sales engineer.

WILLIAM C. HOWARD, JR., who was formerly president and general manager of Leader Tractor & Implement Corp., Richmond, Va., is now an industrial analyst for the motor vehicle division of National Production Authority of the Department of Commerce. Howard was instrumental in founding the SAE Virginia Section, and was its first secretary.

S. P. HORE, who has been working with the Defense Department of the Indian Government in connection with repairs, development and testing of earthmoving machinery and vehicles, has joined the Madras Institute of Technology as assistant professor of automobile engineering. The new institute, at present the only one of its kind in India, offers graduate studies in automobile and aeronautical engineering, electronics, and instruments.

HERBERT N. REITZ, of Hamilton Standard Division, United Aircraft Corp., was recently promoted from engineering control supervisor to assistant to the chief engineer. He will be responsible for the administration of a number of engineering department activities.

F. E. CARROLL, JR. has accepted the position of assistant chief engineer at United Aircraft Products, Inc., Dayton, Ohio. He was previously at Wright Field in the installations branch of the powerplant laboratory.

BENSON FORD, of Ford Motor Co., has been elected Protestant national co-chairman of the National Conference of Christians and Jews. He succeeds **CHARLES E. WILSON**, president of General Motors Corp., who resigned last winter after accepting the post of director of Office of Defense Mobilization. The National Conference of Christians and Jews was founded in 1928 to combat prejudice and promote understanding and cooperation among Protestants, Catholics and Jews.

Continued on Page 110

Personals
Continued

PAUL H. ROGERS is now employed at the armament test division, Elgin Air Force Base, Fla., on the determination of test requirements. He was previously at the Naval Ordnance Plant in Indianapolis.

FREDERICK C. FREI, who was with Wisconsin Magneto Co., is now special field representative for Motor Supply Co., Phoenix, Ariz.

RALPH M. MORSTAD, who was formerly with the combined maintenance division of the Quartermaster Corps, Department of the Army, is now production specialist with the Ordnance Corps at Butzbach Ordnance Depot.

NATHAN F. VANDERLIPP has been appointed general manager of Bellanca Aircraft Corp., New Castle, Del. He was formerly factory manager at Glenn L. Martin Co., Baltimore.

JOSEPH KIM, formerly with Bendix Products Division, Bendix Aviation, is now engineering assistant to the general manager at Wright Aeronautical Corp., Wood-Ridge, N. J. Kim will be in charge of all plant layout and assembly procedures for reciprocating and jet engines.

DAVID M. DENZER has taken a position with Wright Aeronautical Corp., Wood-Ridge, N. J., while continuing study for a master's degree at Columbia University in New York.

LLOYD F. ENGLEHARDT, formerly associated with Curtiss-Wright Corp's. Airplane Division, is now design engineer at McDonnell Aircraft Corp., St. Louis, Mo.

KENNETH D. ROBERTS has joined Bendix Westinghouse Automotive Air Brake Co., Elyria, Ohio, as experimental test engineer. Roberts was formerly chief engineer at Oildex Sales Co., Colorado Springs.

RICHARD G. CUNNINGHAM, formerly research engineer for Pure Oil Co., is now working on the Air Force research project at the Engineering Experiment Station, The Pennsylvania State College, State College, Pa. **DR. PAUL H. SCHWEITZER** is directing the project, which deals with lubrication problems in jet engines at high altitudes.

HAROLD W. CLOUD, formerly general manager of American Bed & Spring Co., now holds the same position at Continental Die Casting Corp., a division of F. L. Jacobs Co., Detroit.

F. M. BALDWIN, JR. is now fuel metering engineer at Marquardt Aircraft Co., Van Nuys, Calif. Baldwin was formerly with Moye W. Stephens Co., Pomona, Calif.

HARRY WESTLAND, formerly sales manager of the seating division of Ionia Mfg. Co. and lately assistant to the president of Merz Engineering, Inc., of Indianapolis, will be partner in a new company to be known as Automotive Engineering Service. Westland will be in charge of the Detroit office of the new firm, which will also have offices in Chicago and Indianapolis.

JOSEPH J. BRETT, who was with the industrial power engineering department of International Harvester Co., Chicago, has now joined Southwest Research Institute of San Antonio, Texas.

GEORGE W. SAWIN, since 1941 president of B. F. Goodrich Rubber Co. of Canada, Ltd., resigned June 30 for reasons of health. **IRA G. NEEDLES** has been elected to succeed him, **JOHN L. COLLYER**, president and chairman of B. F. Goodrich, has announced. Needles has been with the Canadian company since 1925, and was elected vice-president in charge of sales in 1945.

Students Enter Industry

Continued from Page 89

WILLIAM J. KASTNER (Catholic University of America '51) is with the Bureau of Ships, Department of the Navy, Washington, D. C.

EUGENE E. HARVEY (Bradley University '51) is in the engineering department of Allis-Chalmers Mfg. Co., Springfield, Ill.

ELIAS L. CORPAS (Carnegie Institute of Technology '51) is at the Lewis flight propulsion laboratory of the National Advisory Committee for Aeronautics, Cleveland, Ohio.

GEORGE G. POWELL (University of Toronto '51) is with Goodyear Tire & Rubber Co. of Canada, Ltd., New Toronto, Ont., Canada.

JOHN A. PRITZLAFF (Northwestern University '51) is in the Navy aboard the U.S.S. C. J. Badger.

EVERETT W. OPDAHL (Rensselaer Polytechnic Institute '51) is a draftsman for Grumman Aircraft Engineering Corp., Bethpage, N. Y.

JOSEPH TENOPYR, JR. (New York University '51) is a research and development officer at Wright-Patterson Air Force Base, Dayton, Ohio.

WILFERD L. ANTONSON (Oregon State College '51) is at Fiberboard Products, Inc., Portland, Oregon.

WILLIAM MERLE OBLAK (University of Colorado '51) has joined Shell Chemical Corp., at Pittsburg, Calif.

WILLIAM A. EVALENKO, JR. (New York University '51) is a pilot with the Air Force at Mitchel Base, N. Y.

CLARENCE S. BROWN, JR. (San Diego State College '51) is a sales engineer with Swedlow Plastics Co., Los Angeles, Calif.

RICHARD R. TUMLINSON (A & M College of Texas '51) is a maintenance officer with the Air Force at Amarillo Base, Amarillo, Texas.

JOHN W. BECKWITH (Academy of Aeronautics '51) is a design engineer with Consolidated Vultee Aircraft Corp. at Fort Worth, Texas.

JOSEPH T. CAMARDA (Academy of Aeronautics '51) is with Republic Aviation Corp., Farmingdale, N. Y., as an aircraft inspector.

MERWYN O. FAIMAN (San Diego State College '51) is with Consolidated Vultee Aircraft Corp., San Diego, Calif.

RICHARD F. ELDERKIN (Purdue University '51) has entered the U. S. Air Force.

ROBERT BRYAN ENGLISH (A & M College of Texas '51) is in Fort Worth, Texas, with the Air Force.

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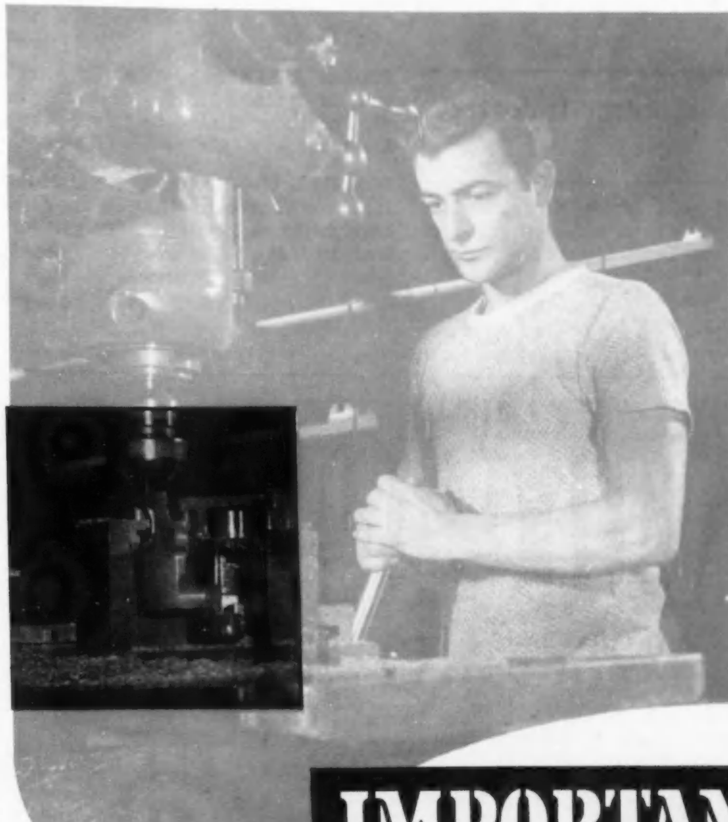

Students Enter Industry

Continued

SHELDON FOX (College of the City of New York '51) is a design engineer with Airborne Instruments Laboratory, Mineola, N. Y.

PHILIP J. STELMASHUK (Case Institute of Technology '51) is a machine designer for Motch & Merryweather Machinery Co., Cleveland, Ohio.

WARREN G. CRAIG (General Motors Institute '51) is with GMC's Fisher Body Division, Hamilton, Ohio, as foreman in the quality standards department.

GORDON W. JOHNSON (Northrop Aeronautical Institute '51) is a draftsman for North American Aviation, Inc., Los Angeles.

GERALD M. LEFOLEY (Rhode Island State College '51) is now a junior engineer with Boeing Airplane Co. in Seattle, Wash.

RICHARD J. SADORF (Northrop Aeronautical Institute '51) is an aircraft controller with the Air Force. Lieutenant Sadorf is stationed in Duncanville, Texas.

JAMES SHERWIN WARNICK (Southern Methodist University '51) is a sales and service engineer with Waukesha Sales and Service, Inc., Dallas, Texas.

ROBERT WILLIAM BACHMANN (Purdue University '51) is now with Cummins Engine Co., Inc., Columbus, Ind.

DEXTER P. DORGAN (California State Polytechnic College '50) is now an inspector with C. F. Braun & Co., Alhambra, Calif.

CHARLES E. BALLARD (Purdue University '50) is now at Caterpillar Tractor Co., Peoria, Ill.

LYLE O. BOWMAN (Oregon State College '50) is an associate research engineer for California Research Corp., Richmond, Calif.

CHARLES J. JACOBUS (Northwestern University '50) is with White Motor Co., Chicago, Ill., as assistant to the service manager.

WILLIAM R. HIPPLE (Case Institute of Technology '50) is in the Air Force in the flight test division at Wright-Patterson Base, Dayton, Ohio.

BERT ALVAN STRAUB (California State Polytechnic College '50) is a gear engineer with U.S. Electrical Motors, Inc., Los Angeles, Calif.

ROSS S. KARLSON (Massachusetts Institute of Technology '50) is in the Army as an engineering aide at Aberdeen Proving Ground, Md.

HOWARD G. ANGLE (University of Wisconsin '50) is in the engineering department of A. Kieckhefer Elevator Co., Milwaukee, Wis.

ALBERT W. BITZER (Carnegie Institute of Technology '50) is a trainee with Heintz Mfg. Co., Philadelphia.

MORGAN B. EILERT JR. (Northrop Aeronautical Institute '50) is a draftsman with Lockheed Aircraft Corp., Burbank, Calif.

JACK EDWARD CHARIPAR (University of Michigan '47) has completed graduate work at the Chrysler Institute and is staff research engineer with the engineering research division of Chrysler Corp., Highland Park, Mich.

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2769
INTERNATIONAL HARVESTER "L-195" Roadliner tractors are standard equipped with the Holley AA-1G Carburetor and the Centri-Vac Governor combination. The carburetor governor combination gives positive power control based on engine speed.
HOLLEY
Carburetor Co.
DETROIT 4
For Half a Century—Original Equipment Manufacturers for the Automotive Industry.
HOLLEY
USA
HOLLEY
CENTRI-VAC
GOVERNOR

Students Enter Industry

Continued

JOSEPH C. BEHNE, JR. (A&M College of Texas '51) is an aviation electronic technician mate with the Navy.

STEPHEN P. HICKS (University of Minnesota '51) is assistant general manager and consulting engineer for Hicks Motor Co., Hicks Oil Co., and Power Implement Co., Pipestone, Minn.

DAVID P. ZIMMERMAN (Purdue University '50) is in the development section of the U.S. Naval Ordnance Plant, Indianapolis, Ind.

JOHN MERRITT PERKINS (Northrop Aeronautical Institute '50) is a wind tunnel model design draftsman at North American Aviation, Inc., Los Angeles, Calif.

EVAN W. WOOD (Carnegie Institute of Technology '51) is with Factory Mutual Insurance Co., engineering division, Cleveland, Ohio.

JULES DUVAL (Tri-State College '50) is now a design engineer with Vend Co., Kansas City, Mo.

ROBERT L. TROXELL (University of Colorado '50) is now with the Army's 3rd Armored Division, Fort Knox, Ky.

JOHN F. LEAMON (Purdue University '50) is with Trans World Airlines, Inc., in Kansas City, Kans.

JOHN L. LAVOIE (University of Colorado '50) is now with General Electric Co. in Lockland, Ohio.

JOHN DANIEL JACKS (Northrop Aeronautical Institute '50) is a draftsman for Northrop Aircraft, Inc., Hawthorne, Calif.

GORDON W. HOLLENBECK (Parks College '50) is a Navy fighter pilot stationed at Jacksonville, Fla.

EDWARD W. COBURN (Tri-State College '50) is a sales engineer with Warren Steam Pipe Co., Warren, Mass.

HAROLD W. FODDY, JR. (University of Colorado '50), who was with GMC Detroit Diesel Engine Division, has been recalled to the Air Force at Lackland Base, Texas.

RICHARD L. STILES (Lehigh University '50) is an assistant project engineer for Baldwin-Lima-Hamilton Corp., Philadelphia, Pa.

LAWRENCE C. FITCH (Marquette University '50) is an assembly technician at GMC A.C. Spark Plug Division, Milwaukee, Wisc.

TED E. DANIELS (Notre Dame University '50) is now a project engineer with Stewart-Warner Corp., South Wind Division, Indianapolis, Ind.

GORDON C. MOREY (Bradley University '50) is a design engineer with Day & Zimmerman Co., Texarkana, Texas.

THADDEUS J. SAWA (Bradley University '50) is now in the U.S. Army Chemical Service.

ANDREW G. KOLINOFSKY (Indiana Technical College '49) is now a draftsman with Glenn L. Martin Co., Baltimore, Md.

PAUL E. JOHNSON (Bradley University '50) is a sales engineer for Westinghouse Air Brake Co., Wilmerding, Pa.

PETER W. GUTTIERI (Academy of Aeronautics '49) is now an aviation cadet in pilot training at Greenville Base, Miss.

JOSEPH G. MILLER (University of Wisconsin '50) is with Miller Bros. Iron and Metal Co., Milwaukee, Wis.

ROBERT C. BIVONA (Oklahoma University '50) is employed at the Aberdeen Proving Ground, Md.

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Students Enter Industry

Continued

RICHARD C. BOWLES (University of Southern California '50) is a piping designer for C. F. Braun & Co., Alhambra, Calif.

JAMES A. YOUNG (California State Polytechnic College '50) is now with Owens-Illinois Glass Co., San Jose, Calif.

EDWARD E. MULLEN (Cal-Aero Technical Institute '50) is a draftsman with General Electric Co. in Richland, Wash.

RICHARD W. BUBIER (University of Maine '50) is with Stone & Webster Engineering Corp., Boston, Mass., as a draftsman.

DEWEY A. SHERAR (University of Southern California '50) is a field service representative for North American Aviation, Inc., at International Airport, Los Angeles, Calif.

DEWAN D. FORESTER (University of Michigan '50) is a product tester with International Harvester Co., Fort Wayne, Ind.

ROBERT K. COOPER (University of Wichita '50) is district manager for Waukesha Engine and Equipment Co. in Casper, Wyo.

JOHN B. CLARK, JR. (University of Michigan '50) has received his master's degree from Michigan and is now with Continental Aviation and Engineering Corp., Detroit.

RUSSELL SCHUCKER (University of Illinois '50) is with Skiles Oil Corp., Mt. Carmel, Ill.

WILLIAM D. SULLIVAN (University of Wisconsin '50) is a sales engineer with The Sullivans of Madison, Madison, Wis.

JOSEPH KLEIN (Indiana Technical College '49) is now with Republic Aviation Corp., Farmingdale, N. Y., as a draftsman.

RICHARD J. LYSIAK (Aeronautical University '50) is now an aviation electronics technician with the U.S. Navy in Memphis, Tenn.

JAMES R. GRAY (Aeronautical University '50) is with GMC Aeroproducts Division, Dayton, Ohio.

HAROLD W. AUSTROW (University of Michigan '50) is a stress engineer for Jered Engineering Co., Detroit, Mich.

ALVIN H. RAND (University of Washington '50) is with Western Gear Works, Seattle, Wash.

DON P. LARKIN (Northrop Aeronautical Institute '50), formerly with Lockheed Aircraft Corp., Burbank,

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Students Enter Industry
Continued

Calif., is now awaiting recall to the Air Force as an aviation cadet.

ALAN LAWRENCE BINGHAM (University of British Columbia '51) is a sales engineer with Wilson Equipment Co., Vancouver, B.C., Canada.

ALFRED G. BERGER (New York University '51) is now a junior engineer for Wright Aeronautical Corp., Wood-Ridge, N. J.

ROBERT J. FERGUSON (Michigan State College '51) is with A. C. Spark Plug Division of General Motors Corp., Flint, Mich., as manufacturing development engineer.

EDWARD O. HOBDAY (Parks College '51) is with the U.S. Air Force at Stewart Base, Smyrna, Tenn.

RAYMOND JOSEPH JOZEFOWICZ (University of Detroit '51) is with O&S Bearing Co., Detroit.

ROBERT C. JUNG (University of Wisconsin '51) is with the Navy as an ensign on the U.S.S. Corson.

EARL C. REED (Utah State College '51) is in the gas turbine research section of Boeing Airplane Co., Seattle, Wash.

RICHARD E. CRANDALL (Oregon State College '51) is now with Hyster Co., Portland, Ore.

GIM CHAN WONG (University of Wisconsin '51) is a production engineer for Yates-American Machine Co., Beloit, Wis.

JOHN A. RISSLER (University of Illinois '51) is a draftsman with GMC Electro-Motive Division, La Grange, Ill.

HAROLD THOM, JR. (University of Michigan '51) is in the management training program of Budd Co., Detroit.

RICHARD S. SCHEIRMAN (University of Oklahoma '51) is with Standard Oil Co. (Ind.), Sugar Creek, Mo.

HENRY K. LANZ (Yale University '51) is with the helicopter division of Bell Aircraft Corp., Niagara Falls, N. Y.

JOHN JANOSTAK, JR. (Wayne University '51) is at Crawford Door Co., Detroit.

KENNETH I. BRENNER (University of Michigan '51) is in Rockford, Ill., with Sundstrand Machine Tool Co.

WILLIAM STIRLING (University of Toronto '51) is with the maintenance section of General Motors Corp. of Canada, Oshawa, Ont.

SHERWIN W. CORLIN (Wayne University '51) is an industrial engineer with Wolf Detroit Envelope Co., Detroit.

Students Enter Industry
Continued

ROBERT J. YOUNG (University of Pittsburgh '51) is with Aluminum Co. of America, Pittsburgh, as a design engineer.

CLINTON POELLET (University of Michigan '51) is at GMC Buick Motor Division, Flint, Mich.

JOHN J. JARVIE (University of Michigan '51) is a detailer draftsman in the body engineering section of Ford Motor Co., Dearborn, Mich.

ARTHUR P. AHRENDT (University of Illinois '51) is a 2nd lieutenant at Wright-Patterson Air Force Base, Dayton, Ohio.

EDMUND L. PRICE, JR. (Pennsylvania State College '51) is a junior engineer with the Pennsylvania Railroad Co. in Altoona, Pa.

LYNN L. BRADFORD (Wayne University '51) is employed at the U.S. Naval Gun Factory, Washington, D.C.

GERHARD PEITSCH (University of Michigan '51) is a junior engineer on hydraulic design at Consolidated Vultee Aircraft Corp., San Diego, Calif.

NORMAN E. WOOD (West Coast University '51) is with North American Aviation, Inc., Downey, Calif., as a research analyst.

JOSEPH C. CAMPBELL, JR. (University of Pittsburgh '51) is at the Edgar Thompson Works of United States Steel Co., Braddock, Pa.

RICHARD J. PRITZLAFF (University of Wisconsin '51) is production line foreman at the Saginaw Malleable Iron Plant of GMC Central Foundry Division, Saginaw, Mich.

ANDREW M. KRAWICZ (Yale University '51) is an engineer in training at Fafnir Ball Bearing Co., New Britain, Conn.

RAYMOND J. WROBEL (University of Michigan '51) is with the Detroit Tank Arsenal, Center Line, Mich.

ROBERT W. COLLIER (University of Michigan '51) is in the engineering department of General Railway Signal Co., Rochester, N. Y.

ROBERT A. BRESNAHAN (Villanova College '51) is a materials engineer with the Air Materiel Command at Wright-Patterson Air Force Base, Dayton, Ohio.

KERRY L. BERKEY (University of Michigan '51) is in the powerplant laboratories at Wright-Patterson Air Force Base.

WILLIAM R. PETTIGREW (Case Institute of Technology '51) is a junior designer for Ovens for Industry, Cleveland, Ohio.

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Students Enter Industry

Continued

LeROY B. THOMPSON (Carnegie Institute of Technology '51) is with Westinghouse Electric Co., East Pittsburgh, Pa.

GLEN W. PUTNEY (Oklahoma A & M College '51) is now with the Texas division of Dow Chemical Co., Freeport, Texas.

JACK E. HARRINGTON (Lawrence Institute of Technology '51) is a senior engineer for Standard Steel Spring Co., Detroit.

CLARENCE EDWARD YOUNGMAN (Parks College '51) has been ordered to active duty with the U. S. Air Force Reserve at Lackland Base, San Antonia, Texas.

DONALD A. KAEHLERT (Parks College '51) is an engineering officer in the U. S. Air Force Reserve, and is at present awaiting orders.

RICHARD G. BECK (University of Iowa '51) is a junior engineer in the fuels and lubricants service division of Standard Oil Co. (Ohio) in Cleveland.

L. ABBOTT LEISSLER (Purdue University '51) is an engineering aide in the Lewis flight propulsion laboratory of the National Advisory Committee for Aeronautics, Cleveland, Ohio.

ALBERT E. SCHOENHEIT (Lawrence Institute of Technology '51) is now with North American Aviation, Inc., Los Angeles, Calif.

HERMAN H. CURRY (University of Florida '51) is a design engineer for Lockheed Aircraft Corp. in Marietta, Ga.

ROBERT H. SMITH (Bradley University '51) is now a test engineer with General Electric Co., Schenectady, N. Y.

HENRY F. THATE III (California State Polytechnic College '51) is at the Martinez Steam Plant of Pacific Gas and Electric Co., San Francisco, Calif.

DONALD J. MILLER (Indiana Technical College '51) is a junior designer in the design operations section of Chance Vought Aircraft Division of United Aircraft Corp. in Dallas, Texas.

JOHN C. PAOLUCCI (Montreal University '51) is now a maintenance engineer with the Montreal Transportation Commission.

MITCHELL SHOELSON (Illinois Institute of Technology '51) is at the U. S. Naval Gun Factory, Washington, D. C.

GEORGE J. HOLLAND (Parks College '51) is an Air Force pilot stationed at Ellington Base, Houston, Texas.

Applications Received

The applications for membership received between July 10, 1951, and August 10, 1951 are listed below.

Atlanta Group

George Ward Foote, Lloyd W. Moore, E. S. Parks, W. H. Roberts, William H. Whitworth.

Baltimore Section

Andrew G. Kolinofsky, Howard D. Pulmly, Jr.

Buffalo Section

Robert James Collins, Robert Dietrich Gruntz.

Canadian Section

Albert Sherwood Barber, Robert S. Hart, John Frederick Jones, Maj. Charles Gray Provan, Clifford Sawyer, Robert Stuart Warner, Oswald Arnold Zepik.

Central-Illinois Section

Charles E. Ballard, Harry J. Goeppinger, Warren Rose Salzman, Harry J. Schroeder.

Chicago Section

Florine Klatt Bender, William E. Broadfoot, Marvin Louis Davis, Donald E. Ferro, John E. Fitzgerald, Helen D. Hoover, James Edward Houghton, Eugene H. Middendorf, Clarence P. Niebow, Elmer Allen Pagel, Raymond Louis Steier.

Cleveland Section

Robert R. Hunter, C. K. James, Charles F. Laundy.

Colorado Group

Murray B. Chidester.

Dayton Section

Lee T. Bebout, Alfred W. Carey, Jr., Earl R. Kunz, Charles Edward Powers.

Detroit Section

Gerald N. Bergum, H. O. Brakenberry, James B. Ellsworth, Daniel Wolf Feldman, William Davis Gauthier, Edgar A. Hahn, Robert T. Herdegen, Jr., Philip W. Lett, Jr., William Evan Little, William T. Lloyd, Walter L. Luptowski, Richard John Matt, Russell H. Nutter, John D. Roach, Jr. Rapha R. Rolph, Ralph L. Skinner, Jr., Charles J. Smith, Arnold W. Steckling, Theodore J. Steinmetz, Hugo H. Traeger, Franklin Walter, Thomas Joseph Wilkinson, Charles M. Wright, Louis Paul Zetye.

Hawaii Section

Herbert K. T. Choy.

Indiana Section

Kenneth Walter Berner, Stanley Vaughn Lemmon.

Continued on Page 124

Applications Received

Continued

Kansas City

H. A. Lewis, Gene R. McLaughlin.

Metropolitan Section

Edward A. Drury, Joseph D. Fina, Hugh Harvey, Jesse R. Hollins, Joseph Klein, John Mockovciak, Jr., Reginald William Pauley, James J. Rowe, Alaric C. Schliewen.

Mid-Michigan Section

Joseph F. Hein, Paul Moss.

Milwaukee Section

Joseph G. Arnold, Glenn M. Frazier, John Arthur Langley, Robert J. Muzzy, Joseph A. Zerkel.

Montreal Section

Robert L. Dunsmore, W. S. McAllister.

New England Section

Milton E. Cook.

Northern California Section

John B. Hoey, Eugene B. Kent, Walter E. Lauritzen, Louis G. Oleari, Jess M. Ritchie, Roland James Wolfe.

Northwest Section

Robert E. West.

Oregon Section

Leslie Tyrus Cooper, James A. Oeder, Rege A. Ott, David T. Saunders.

Philadelphia Section

Asa Edward Snyder.

Pittsburgh Section

Wayne M. Gersen, G. R. Greenslade.

Salt Lake City Section

Lloyd James Verket.

San Diego Section

Victor E. Bitter, H. H. Ferris, Jr. Arthur E. Stone, Tibor Ungar, Milton G. Wegeforth.

Southern California Section

Boyd Dahle, Phillip B. Garner, Marvin Earl Russell, Sr., Earl W. Seely, Harold W. Smith, Earl Charlton Swallow.

Spokane-Intermountain Section

Edward W. MacKenzie.

Syracuse Section

Robert Edward Jones, Richard A Sturley.

Applications Received
Continued

Texas Section
Lt.-Col. John H. Ford, Jr.

Washington Section
Dayton S. Barrows, Raymond A. Coulombe.

Wichita Section
Kaye Charles Heller.

Williamsport Section
Clinton T. Brion, Paul Gervinsky, Clifford Ameigh Pfleegor, Jr.

Outside of Territory Section
Emile Louis Dubois, Walter H. Freitag, Alvin Verle Haptonstall, William T. Hunt, Harley M. Newcomb, Oris L. O'Daniel, Charles A. L. Ruhl, Paul H. Sward.

Foreign
Frederick John Pascoe, England; John Albert Radford, England; Sondhi Mantosh, India.

New Members Qualified

These applicants qualified for admission to the Society between July 10, 1951 and August 10, 1951. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (SM) Service Member; (FM) Foreign Member.

Baltimore Section
Marshall Brownlee Heizer, Jr. (J).

Canadian Section
Walter H. Cox (A), V. L. Van Der Hout (A).

Central Illinois Section
John M. Corkill (J), Edgar W. Myers (M), Harold H. Wagner (M), DeWitt D. Wycoff (A).

Chicago Section
Robert Thomas Andrew (A), William Howard Borling (J), A. Wilbur Brandt (A), R. N. Coleman (M), Blake H. Hooper (J), Hugo C. Lange (A), Truman C. Mason (M), Charles W. McDonald (A), I. E. MeWethy (A), Arthur O. Radke (J), William C. Swanson (J), Renso John Vannelli (J), Frank R.

Continued on Page 126

New Members Qualified

Continued

Wemheuer (M), Fred William Wilken (A), Grady J. Zilligen (A).

Cleveland Section

Robert G. Hill (J), W. C. Hohmann (A), Howard L. Hopkins (M), Walter Eugene Kappus (J), Norman C. Zollar (A).

Detroit Section

Richard Allchin (J), Thomas E. Arnold (M), Orin U. Bales (M), P. Ken Cummings (J), George J. DeLisle (M), Richard H. Fashbaugh (J), Mark D. Gross (J), R. H. Horner (M), William E. Judy (M), Sheldon Kavieff (M), Mitchell C. Kazen (M), George H. Kohring (J), Kenneth V. Lundquist (M), Clayton C. Luther (M), Max R. Miller (J), James T. Moore (A), Thomas O. Muhn (J), George Henry Muller (M), William L. Woodward, Jr. (A), Robert Ryndress (A), John J. Nopper (A), Robert S. Phillips (?), Robert Bedford Pogue, Jr. (J), Edmund J. Popiel (M), John W. Powell (A), Ralph John Rasmussen (?), George Seeger, Jr. (J), Stephen J. Shomberger (J), W. A. Smith (?), Richard H. Stout (J). F. M. Urban (A), Albert F. Welch (J), Frank A. Westenkirchner (J), James S. Winterhalter (M), James T. Moore (A).

Hawaii Section

Chancellor J. Carter (A), Jack R. Morris (J).

Indiana Section

Alan S. Clark (A), Edward A. Poste (M), Milo M. Schalla (M), Harold W. Stoelting (M).

Kansas City Section

Meredith C. Howell (A).

Metropolitan Section

James J. Irwin (M), John A. C. Krulish (J), David William Mansell (M), James B. Peeso, Jr. (M), Mark H. Smith (M), John H. Vanderbilt (J).

Mid-Continent Section

Robert J. Masar (J).

Mid-Michigan Section

John W. Burnside (A), Martin J. Caserio (M), Roy J. Griffin (M), Roger A. Huntington (A).

Milwaukee Section

Loren D. Gilmore (M), Robert Walter Hanak (M), Walter F. Laster (M), Joseph Morvak (M), William G. Pierce (M).

Mohawk-Hudson Group

G. Warren Hull (A), Edwin Nelson Morey (A).

Montreal Section

Jules George Grandon (M), Robert F. Grannary (A), William O. Horwood (A), John McHugh (M), Joseph Arthur William Torch (A), Edward John Wickenden (J).

New England Section

John Ellis Jorgensen (A).

Oregon Section

Norman B. Chew (J), Jack D. Mitchoff (A), Ray Preston (M).

Philadelphia Section

Harold C. Grannas (M), Stanley A. Olsen (M), John J. Reitano (M).

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New Members Qualified

Continued

Pittsburgh Section

C. F. Sterbutzel (A).

St. Louis Section

Eph Howard (J).

Salt Lake Group

Reuben W. Ludtke (A), Richard D. Van Derck (J), James R. Wright (J).

San Diego Section

Lewis M. Anderson (M), Dennis Owen Samuelson (M), Howard J. Streich (M).

Southern California Section

Marshall Wood Paxton (M).

Southern New England Section

Erwin F. Grimmeisen (M).

Syracuse Section

Frank Germano (J).

Texas Section

Allister L. Presnal (J).

Twin City Section

Richard H. Donaldson (A), Burnett V. Iverson (A).

Virginia Section

Robert Earl Williams (A).

Washington Section

Major C. A. Main (SM).

Atlanta Group

Ernest D. Troutman, (A).

Williamsport Group

Fred Muller, Jr. (M).

Outside of Section Territory

Russel A. Anderson (A), Edward J. Bergin (A), John C. Drummond (A), Frank Fahland (M), Virgil Fiksdal (A), Frederick George Forster (A), Carl Glambeck (A), Glenn C. Gridley, Jr. (J), James Kennedy (A), Graeme E. MacKinnon (A), Robert W. Parker (A), Robert R. Roth (M), Charles A. Sereno (M), Delbert A. Smith (A), John Neville Stewart (A), J. H. Walters (A), Ist Lt. John C. Worthington (J).

Foreign

Faiyaz Ali Khan (FM), Pakistan; Robert Boyazis (FM), Belgium; Vaman Shrinivas Kudva (FM), India; Frank W. Stokes (FM), England.

For the Sake of Argument

On Beating About the Bush

By Norman G. Shidle

There's much to be said for "beating about the bush." Like any other tool of human relations, it accomplishes most when used by a man who is clear about his objectives. The longest way round *is* often the shortest way there.

"Beating about the bush" can serve a business conference participant much as squinting at clouds serves the experienced mariner. Reactions will help him chart his course to avoid a possible storm . . . save the need to find ways out of a tempest after it strikes.

"Beating about the bush" may help to avoid direct issues, make "showdowns" unnecessary. That's often the same thing as avoiding frictions or hurts. Latent possibilities for hurting somebody lie in every showdown. Somebody is likely to lose face, have to give in, admit a mistake—all distress producers for most of us when on the losing side. The man who opens a pleasant sidelane down which we may stroll with him usually moves unimpeded. Our resistance rises to the one who demands his rights on the main thoroughfare where we are dawdling.

"Beating about the bush" is sparked as often by kindliness as by evasiveness, by tactfulness as by cowardice. It usually reflects a mind looking for a mutually comfortable route to common ends. The beater-about-the-bush is obviously not spoiling for a fight.

Of course, beating about the bush by a man who doesn't know what he's looking for can be an unconscionable time-waster . . . and strictly an annoyance to those who rate decision more potent than unfoldment. There's always the danger that when you just lay an idea down quietly nobody will pick it up . . . or that somebody will kick it aside with irritation. But when an idea is picked up without pressure from the dropper, it gets a warmth of attention never accorded a radio commercial—or its business conference equivalent.

The beater-about-the-bush isn't always the confused oaf Efficiency Edgar thinks him.